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Usability Study for the Design of a Communicator for ICU Patients with Communication Difficulties

Master Thesis

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Abstract

Most of the patients that reside in the intensive care unit experience fear, frustration and high levels of anxiety as they are not able to communicate properly. In this sense, the use of communication tools can be helpful to reduce the frustration levels and also, to improve the efficiency and the speed of the communication.

The objective of this work, is to design a tool that allows solving the communication problems that patients suffer when they are admitted in the intensive care unit.

In order to achieve the objective of this work, a qualitative study that involved interviews with former patients, hospital staff members and family relatives was performed. Afterwards, the design of a prototype was developed to later conduct and analyze usability evaluations with former patients, hospital staff members and patients relatives.

The results expose that participants of the usability evaluations were able to perform most of the tasks effectively.

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Abbreviations

AAC	Augmentative and Alternative Communication
ASD	Autism Spectrum Disorders
GUI	Graphic Interface Unit
GSM	Global System for Mobile Communications
ICU	Intensive Care Unit
PCC	WinCE-based Pocket PC
RASS	Richmond Agitation Sedation Scale
UCD	User-Centered Design
VOCA	Voice Output Communication Aids
WP7	Windows Phone 7

Chapter 1

Introduction

1.1 Motivation

When a person has problems to produce speech correctly or fluently, or has problems associated to his voice, then he has a speech disorder. Examples of this type of disorders can be when a person that stutters or when he has problems producing sounds.

On the other hand, when a person has problems to understand others, or difficulties to share thoughts, ideas or feeling, then, he has a language disorder. For instance, a stroke can result in aphasia.

Both disorders can occur as a consequence of medical problems or by known causes [1].

Most of the patients, while residing in the Intensive Care Unit (ICU), experience high levels of frustration associated to the impossibility of communicating effectively. In this sense, the use of communication tools can be perceived as helpful by patients to reduce the frustration levels and also, to improve the efficiency and the speed of the communication [15].

The introduction of communication tools in preoperative stages to ICU admission appears to have beneficial effects in patient's communication. Mainly, as the patient is able to master the tools without being in the ICU environment with all the complexity that this adds [11].

However, not all the patients are admitted in the intensive care unit as result of scheduled procedures. In these situations, patients are not always able to learn and master the available tools for communication. To make worse the situation, generally, ICU patients are not in their best physical and psychological condition to learn and to use these tools. As a consequence, it generates a greater obstacle at the moment of communicating with the people in the intensive care unit.

In an era where technology availability is exponentially growing, we can see that it is not being applied in intensive care unit environments to a great extent. As an example, patients with speech language impairments are still using paper & pencil, cardboards or just hand gestures to communicate. Conversely, in other health areas, we can see technology applications such as the "da Vinci Surgical System", that allows performing minimally invasive surgeries using a robot controlled by a surgeon located in a different geographic place than the patient [2].

Current technology can provide communication tools for ICU patients with speech disorder, and the current work will focus on providing a mobile-based prototype supporting these patients' communication with health professionals, family and friends.

1.1.1 Objectives

The above-mentioned difficulties pose a troublesome scenario where an immediate solution is needed. This solution should satisfy all the parts involved with special emphasis in the patient. In order to provide an adequate solution, the first step is to understand the intensive care unit environment and how people related in it.

Afterwards, we will proceed to develop a tool that allows solving the communication problems that patients suffer when they are admitted in the intensive care unit.

1.1.2 Specific Objectives

Next are presented the specific objectives defined for this work:

- To understand the context, the patient's needs and how he relates with his family and the hospital staff while residing in the intensive care unit
- To design a prototype application for tablets centered in the patient, that is easy to use and understand
- To elaborate an evaluation plan for the prototype design
- To evaluate the prototype design with a specific group of users according to the evaluation plan
- To analyze the results obtained
- To identify problems and propose enhancements to improve the prototype design

1.2 Document Structure

This chapter includes the introduction, the motivation and the objectives behind this master thesis.

Chapter 2 contains a brief definition of Augmentative and Alternative Communication. In addition, the Augmentative and Alternative Communication Systems are explained. Lastly, different types of Augmentative and Alternative Communication techniques are detailed divided by low or high technology.

On Chapter 3, a literature review is presented about research works dealing with the communication problems that patients have while residing in the intensive care unit.

Chapter 4 describes the design and execution of the qualitative analysis performed in cooperation with the Hospital Universitario de la Princesa.

On Chapter 5, the findings of the qualitative analysis performed in Chapter 4 are summarized.

Chapter 6, contains the developed design of a prototype for patients with speech language impairments. The description, the content and the navigation map of the prototype are detailed in this chapter.

Chapter 7, exposes the design and execution of the usability evaluation performed on the prototype defined on Chapter 5. All the steps necessary to perform the tests are explained in this chapter along with the tasks defined.

On Chapter 8, the collected data, as a result of the usability evaluation of Chapter 7, are presented detailed by task and by participant. Finally, the analysis, the problems identified classified by severity and the suggested improvements are presented.

Chapter 9 presents the conclusions and future lines of work of the master thesis presented.

Chapter 2

Communication Systems

2.1 Augmentative and Alternative Communication

According to American Speech Language Hearing Association, Augmentative and Alternative Communication can be defined as any form of communication (other than oral speech) that is used to express thoughts, needs, wants, and ideas. People with severe language impairment usually rely on Augmentative and Alternative Communication (AAC) to supplement or replace their non functional speech. Impaired people usually uses tools such as communication boards or electronic devices to express themselves. [5]

2.2 Aided and Unaided Augmentative and Alternative Communication Systems

Augmentative and Alternative Communication Systems are usually classified as either involving aided or unaided communication.

Aided AAC systems are those identified by the use of additional elements such as communication boards, line drawing symbols, photographs, flashcards and texture-based symbols. Technological advances have led to the development of commercial devices that produce recorded or synthesized speech. These speech generation devices are becoming widely used in AAC interventions.

Researchers have investigated considerably the issues that surround selecting appropriate symbols for people that require AAC. In general, results from several studies suggest that for concrete objects or nouns, icon symbols are easier to learn to use in AAC systems. However, there does not appear to be best icon symbols for use in aided AAC.

Unaided AAC systems, involve the use of gestures or manual signs. The gestures or signs that a person uses to communicate can be formal or informal and conventional or characteristic of him. Formal gestures include headshakes for communicating yes or no responses. On the other side, informal gestures, might involve idiosyncratic movements such as moving the right leg in some specific manner to communicate a particular message. Another alternative for communicating is to use manual signs. These might be derived from a formal language like the American Sign Language or could also be a modified version to meet the special characteristics of the person [8].

2.3 Types of Augmentative and Alternative Communication

2.3.1 Low Technology Communication

Low technology communication strategies are most frequently used in healthcare settings, as well as in hospice settings and at end-of-life. This category of tools includes a wide range such as alphabet boards, communication boards, pain scales, laser pointers, dry-erase boards and yes/no boards.

Common techniques that facilitate access to communication when a person is speech language impaired or physically limited include partner-assisted scanning, eye gaze, head pointing and E-tran. These techniques are not exclusive between them. On the contrary, they can be used standalone or combined [7].

2.3.1.1 Partner-Assisted Scanning

This technique involves the use of an alphabet board or communication board, where the patient answers with a “yes or no” method. For instance, common methods are looking

up to the ceiling, smiling, nodding and thumbs up. It is important to notice that eye blinks is not a recommended method, as it is an involuntary movement of the human body that can confuse the partner.

After the response method is selected, the partner moves iteratively item by item until the user responds with "yes". When using alphabet boards with partner-assisted scanning, there are some strategies that can be helpful. First, the board design could display all the vowels in first column from left to right with different colors. Patients that suffer from Amyotrophic Lateral Sclerosis (ALS) or Locked-in syndrome have their cognitive reasoning intact. Usually, these patients memorize the colors associated to each letter. Then, when communicating with his partner, they do not need to use the board as they have memorized it. Another possible strategy consists in dividing the alphabet in two half. Once the half is selected, the partner says each of the letters of the group until the patient response "yes" [7] [8].

FIGURE 2.1: Partner Assisted Scanning from http://alsn.mda.org/.

2.3.1.2 Eye Gaze

This technique is useful when the patient is unable to speak, write or point with the finger. Basically, the communication with this technique can be as simple as the partner holding up cards and asking the patient to look at the choice he wants. The number of choices can be limited, as patients with cognitive impairments have difficulties to recognize more choices. Eye-gaze boards can be developed on transparent sheets or using Velcro to attach pictures or words. Generally, these types of boards have from two to eight choices. If they have more options, patients may have difficulties to recognize the

available choices. Nevertheless, this technique can be used with partner-assisted scanning to help to select the available choices [7].

2.3.1.3 E-tran

This technique uses a special eye-gaze board with an encoding system that allows patients to access and to communicate more quickly. The most common encoding systems are color, alphanumeric and symbol numeric. For instance, an E-tran board can have blocks of colors with colored letters inside. Hence, the patient use this encoding system, first he looks at the desired block. Afterwards, he looks to another block that color matches with the letter he wants to select. In this way, the user can communicate any letter of the alphabet using two selections [7].

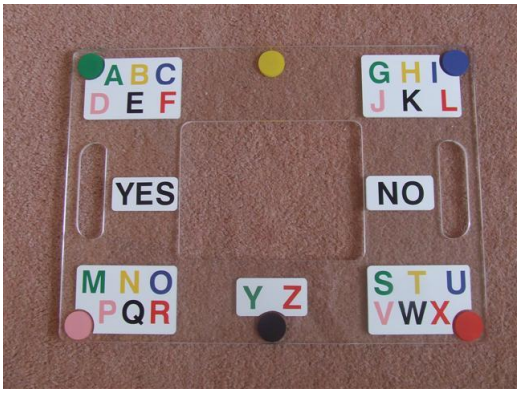

FIGURE 2.2: E-tran Frame from http://www.livingmadeeasy.org.uk/.

2.3.1.4 Head Pointing

Head pointing uses a laser pointer attached to the eyeglasses or a cap. The user points to letters on an alphabet board using head movements or a personalized sheet. In the same way, this method allows users to point objects in the room.

FIGURE 2.3: Head Mounted Laser from http://store.lowtechsolutions.org/.

2.3.2 High Technology Communication

High technology communication systems are devices that range from single message devices to very sophisticated systems such as computers and software programs or any electronic aids to speak. [6]

2.3.2.1 Call Alerts

One of the most common causes of patients' anxiety is the difficulty of calling for help. If a patient can communicate using verbal speech or can make noise, a monitor similar to a baby monitor can be placed in the patient's room. However, patients with communication disorders or severely ill need a reliable alternative to alerting system.

Hospital patients usually have a call alert system or alert device (switch) that is placed within the reach of the patient. If the patient has a problem, he just pushes the switch to call for help. Nevertheless, if the patient has difficulties to use his hands, then, the switch may be placed near a body part that is easier to move such as foot, head or leg [7].

FIGURE 2.4: Call Alert Switch from http://www.gimpgear.us/.

2.3.2.2 Tablets and Mobile Devices

Mobile technology, such as mobile phones and tablets, has become more accessible and available. These devices can have applications with text-to-speech capability that allow patients to communicate effectively if they have the appropriate cognitive skills. In addition, applications with medical communication boards, yes/no functionality, and applications image-based that support spoken and/or printed messages can promote the communication related to healthcare. These mobile technologies also support social engagement and maintain social relationships. For instance, patients with physical impairments can benefit from looking at photos or performing video conferences with friends and family [7].

FIGURE 2.5: Tablet for Autism from http://www.tabletforautism.com/.

Chapter 3

Literature Review

3.1 Introduction

This chapter describes some approaches in the literature to the problematic of communication that people suffer as a consequence of severe speech and language impairments. The domain and context where each approach was performed differs although the common objective is to solve everyday communicative challenges.

The first three papers analyzed in this section are related to communication in intensive care units environments. Next, the following three studies are focused to augmentative and alternative communication for speech impaired persons in a different context of use. Finally, the last paper that appears is oriented to recommendations for developing applications considering older adults as target users.

3.2 Communication in Intensive Care Units

3.2.1 AAC Intervention in the Intensive Care Unit: The Children's Hospital Boston Model [11]

3.2.1.1 Summary

This paper describes a model for preoperative augmentative and alternative communication interventions for patients with scheduled medical procedures in Intense Care Units that will leave them with temporal speech impairments. The model was introduced in the Children's Hospital in Boston in 1994 but it was not until 2000 that the author published it along with the results. During that period, more than 100 patients between 2.8 to 44 years old took part as test subjects. Unfortunately, feedback from all patients was not recorded. The fundamental aspects of preoperative and postoperative are presented in this work along with the strategies that the model encompasses.

According to the author, traditionally, ICUs only focus on the postoperative bedside assessment and intervention where tools such as alphabets, picture boards, writable boards, gaze displays, electrolarynges, small typing systems and digitized recording systems are introduced. However, these interventions may be compromised by patients' inability to process information due to their medical condition, reduced motor and sensory skills as a result of a surgery, lack of glasses or hearing aids and restricted mobility because of temporary restraints that may be necessary during certain periods. Furthermore, severely ill patients see their learning process affected and often experience distress combined with a sense of loss of control.

In some occasions, patients schedule their surgical interventions in advance for later admission in the ICU. If afterwards the medical procedure an expected temporal inability to speak follows, then, a preoperative communication instruction is performed.

The researcher claimed that there are a number of factors that support such a preoperative model of AAC intervention. First, the selection of AAC strategies and techniques lets patients to participate without suffering the stressful situation of being in an ICU and also using fully their processing capabilities. Second, such intervention permits using and gaining experience with AAC strategies prior the medical procedure. Finally, patients

are able to actively participate in their own care and in this manner increase the sense of control in the ICU.

The model structure is divided into three components: Preoperative Intervention, Postoperative Intervention and Discharge Interview. At the same time, the Preoperative Intervention contains several subcomponents:

- General Patient Expectations/Education
- Initial Introduction to Communication Aids
- Vocabulary Selection
- Brief Review of Sensory
- Motor and Literacy Skills
- Introduction to Symbols
- Alternative Access Strategies
- Options for Mounting/Positioning VOCAs
- Voice Message Banking

3.2.1.1.1 Preoperative Instruction

During preoperative instruction, patients are presented to multiple AAC techniques, including picture displays, alphabet displays, eye gaze displays, and simple VOCAs (Voice Output Communication Aids) using direct selection and scanning modes. More than one option is provided since it is likely that a single technique will not be enough to cover the patient needs in full throughout the recovery phase in the ICU. In general, the preoperative instruction sessions are scheduled from 24hs to several months before the medical procedure is executed. Nevertheless, bedside instruction is performed if the patient was already admitted in the ICU.

General Patient Expectations/Education

Preoperative instructional meetings are focused to determine the patient's understating

of the medical procedure that will result in an inability to speak. For achieving this, a general overview of what it may be like to be unable to speak is provided. During the meeting, patients and families may raise issues about related medical information and the corresponding responses are provided along with further material or transferred to other preoperative team members.

Initial Introduction to Communication Aids

Next, patients are introduced to communication tools that are available in the ICU. Currently, from an extensive list of devices, the set was reduced to include only Message Mate 40/600 [25], the LINK and the One-Step switch due to patient's preferences, device reliability in the ICU environment and ease of use.

Vocabulary Selection

In this stage, patients and families are asked to identify appropriate vocabulary for the ICU. Each patient and family member is asked to generate messages that he or she thinks may be necessary while residing in the ICU. Typically, the AAC therapist will provide assistance to generate suitable messages and encourage choosing from 30 to 40 messages at most from a set of predefined messages. Also, the therapist will strongly recommend selecting items that represent their personalities, personal interests and sense of humor.

Brief Review of Sensory, Motor and Literacy Skills

A baseline description of the patient's vision and hearing is established by mean of interviews. If the patient needs corrective glasses or hearing aids, nurses in the ICU will provide them whenever possible. Sometimes, in order to be used in the ICU, glasses or hearing aids need to be modified. Such as the case when the arms of eyeglass frames are detached due to excessive facial swelling.

The patient's motor status is evaluated using a variety of symbols displays with respect to the target size and range of motion. Similarly, patient's ability to apply sufficient

pressure on buttons or membrane keys is also evaluated, as it is needed to use some devices from a reclining position.

With respect to the patient's level of literacy, a brief assessment of the patient's alphabet knowledge is performed as well as the spelling ability of all patients with more than 5 years old.

Once the patient has proved functional literacy skills, a "general topic cue display" is introduced using the first-letter cue strategy. The topic cue contains topics related to the ICU environment such as emotions, pain, breathing, positioning, personal needs and family. Additional topics may also be added such as prayers, stuffed animals or other personal interests. Afterwards, patients are taught how to use the display to introduce topics using first letter cues.

Introduction to Symbols

After the message selection, the next step is to choose symbols. Children under 10 years old are introduced to "Wong-Baker Faces Pain Scale" hence they are able to communicate pain intensity in the ICU. Usually, Picture Communication Symbols are used, as they are available in Boardmarker software. This software also has functionality for creating customized symbols. Therefore, nasogastric tubes and oral intubation symbols were created. Additionally, patients are encouraged by the clinician to create their own symbols using Boardmarker software during the preoperative meeting. The final communication display is printed so patients can take it home and get familiar with the symbols before the medical procedure.

Alternative Access Strategies

A variety of alternatives access strategies are reviewed in the preoperative meeting to prepare the patient with regard to their motor status. Sometimes, after the medical procedure the motor or sensory status can be temporarily affected. The following is a list of the alternative access strategies that the model suggests:

- Unaided Yes/No Response

- Adapted Nurse Call System
- Tactile Direct Selection
- Eye Gaze Direct Selection
- Visual Assisted Scanning
- Single-switch Scanning
- Auditory Scanning

Each strategy is directly associated with the medical procedure executed. For instance, patient with vision impairment cannot use vision-based strategies such as Eye Gaze. In the same way, a patient with a surgery that has not involved the head or the face will not need auditory scanning or tactile direct selection. In addition, all patients are introduced to an adapted nurse call system. If the patient has a VOCA device, the nurse call-message is recorded in it.

Options for Mounting/Positioning VOCAs

One of the patient's concerns is not having almost immediate access to the device or that it may not be available after changing the position in bed. This worry is easily solved with a Universal Mounting Arm and a Dual Lock Fastening System at the bedside.

Voice Message Banking

During this phase, the patient's voice is recorded into a VOCA device to reflect postoperatively his personality and needs. If the patient cannot record his own voice properly due to external factors, a proxy speaker with similar characteristics takes his place for recording. In the recording process, the patient records his voice with the same intonation that he would use daily. The clinician guides the process regarding to articulation and pause time to ensure that each message is well understood. Patients can record the messages as many times as they want until they are satisfied with the results.

Costello remarked several potential benefits that voice banking offers. First, it allows patients to communicate using their own voice, tone and intonation, which preserve his personality during the temporal inability to speak. Next, voice banking lets patients

express clearly and directly their emotions and beliefs. Furthermore, it permits patients and family members connect emotionally and maintain personal relationships over nonsensical messages. Finally, voice banking allows patients to take an active role in their own postoperative care.

3.2.1.1.2 Postoperative Bedside Intervention

After the surgery, the communication tools are brought to the bedside in the ICU. The nurses and medical team assess the level of alertness, the neurological status, the ability to attend to a communication partner, the ability to follow simple directions and the ability to be comforted. Once the patient is determined medically stable, a speech-language pathologist initiates the communication intervention. In some occasions, the patient sometimes arrives at early hours or late in the evening. In these cases, the nurses that are quite familiar with communication tools attach the AAC devices to the bedside to ensure that they are available once the patient is awake. Afterwards, when the patient is wide-awake, nurses relocate the devices at the patient's will for immediate use.

3.2.1.1.3 Discharge Interview

Although a formal interview process was not initially included in the model, informal interviews were carried out. Strengths and weaknesses were gathered from patients and families as well as feedback from nurses and medical staff. Yet, formal questionnaire was still under development when the author published the model.

3.2.1.1.4 Study Results

From the hospital records provided by the author, the most common surgeries were related to craniofacial anomalies (32%), intubation or tracheostomies for airway management (19%), tumors of the face or airway (16%), lung transplantation (15%), compromised airways secondary to venous malformations (11%) and tracheolaryngeal or esophageal reconstruction (7%).

With respect to the communication tools, Message Mate 40/600[21] was the tool widely accepted over other more sophisticated options. Some reasons are described in what follows:

- Simplicity for storing and editing messages
- High quality of the digitalized speech
- Flexibility of access options (from direct selection to single switch auditory scanning)
- Compact size
- Durability
- Easy of editing the display

Concerning to the vocabulary selection process, patients selected approximately 25 to 30 messages for inclusion in the 40 items device grid. Many also reserved at least two spaces for unanticipated messages that could be added later in the postoperative phase.

An analysis of patient-generated messages included in Costello's model, indicated three main categories: personal comfort, medical and psychosocial. The primary personal comfort messages are those related to personal needs, positioning and statements or directives. The psychosocial vocabulary included messages classified as social, emotional, comfort, control, sarcasm and humor, clarification, leisure or entertainment and questions. Finally, the medical category included associated medical issues such as requiring medicine, feeling pain, being sick or to be suctioned.

The usage of voice and message banking reported a positive impact in patients, family members and medical staff. Parents told that hearing the voice of the child had a positive emotional impact. As regards the nursing staff, voice banking allowed them to know the personality and appreciate better the human being behind the patient. Additionally, nurses stated that communication devices often made their jobs easier as they did not have to guess what were the patient's needs or wants. Moreover, they pointed out the patient's high efficiency to communicate urgent needs using the provided AAC devices.

Some patients stated that the usage of Picture Communication Symbols in the postoperative phase facilitated the use and understanding rather than using only text items.

A patient commented that the positioning of the VOCA postoperatively was extremely important. The levels of anxiety of this patient were noticeable raised up every time the device was moved from his sight.

In discharge interviews, many patients reported that they felt they had had a real role in their own care. Likewise, other patients mentioned that they felt respected as they could tell something to nurses or doctors and their requests would be answered.

Family members remarked that they were able to prepare the child and themselves to face the medical procedure as a consequence of following the model. Furthermore, parents felt comfort that his child could communicate with a high degree of independence in their absence.

According to Costello, patient's reports of their experiences with the Children's Hospital Boston model were encouraging with respect to previous studies in the literature. In the discharge interviews that he carried out, patients did not reported feeling exhausted while communicating, isolated, out of control or afraid and anxious because of communication breakdowns. In this regard, most of the patients had minimal difficulties using the communication strategies proposed by the model. This may be the result of the model emphasis on active involvement of the AAC tools as remarked by the author.

From the study findings and although the clinical experience along with anecdotal reports suggested that Children's Hospital Boston Model has substantial benefits, more research is needed to assess the efficiency of model.

3.2.1.2 Analysis

At the moment of performing this bibliographic research, no records or subsequent studies were found about if Boston Children Hospital continued using the proposed model.

The patients that took part in Costello's study did not present any neurological disorder as result of a surgery or beforehand. Therefore, the efficiency of the model was not verified with patients with severe speech impairments as a consequence of a neurological disease. Nevertheless, Costello's findings can be useful for developing an AAC software application for tablet or mobile.

Message Mate 40/600's main purpose is to provide voice banking. However, a software application for mobile or tablet can provide this feature and others as well such as photo storing and viewing, music, games and chat. Furthermore, one of the downsides of Message Mate 40/600 is that storage for messages is limited up to 144 messages. Another drawback that this device uses paper based iconography which is provided by the manufacturer. In this regard, a software application does not depend on paper so practically any image available in digital format can be used.

Costello strongly emphasized in his study that voice banking was one of main features of his model. This feature could be implemented in practically any mobile or tablet device. Though, a drawback on portable devices is the tactile feedback with respect to Message Mate 40/600. The latter one can be equipped with membrane keys with stiffeners that makes it superior over portable devices with only vibration feedback.

As the results from the Children's Hospital Boston model with regards to Picture Communication System were positive, in consequence, the same technique can be used in portable devices. Costello's model presents example messages that are common in pediatric intensive care unit environments. These 113 predefined messages divided into 12 categories, each one embrace a different communication topic. These messages can be helpful as baseline for generating recorded messages in software AAC tools.

The author also stated that a preoperative model for AAC intervention that early addresses speech impairments in the ICU appears to be beneficial. However, there are occasions were patients unexpectedly arrive at the ICU because of accidents or just by other reasons like suffering an acute episode of a disease, previously detected or not. In this case, the preoperative component cannot be applied and therefore the patient may or may not be able to learn how to use the communication tools proposed by the model.

In Costello's study, the patient's age varied from 2.8 to 44 years. In general, the average age admission (United States and United Kingdom) ICUs is approximately 60 years old [20]. Elderly people represent a big percentage of ICU admissions; still, the model was not tested against them.

3.2.2 Communication Boards in Critical Care: Patients' Views [15]

3.2.2.1 Summary

This paper describes a study conducted by researchers with the following objectives: to identify the perceived level of frustration of patients while trying to communicate; determine the level of frustration if a communication board is used to communicate and, lastly, describe the content and format that a communication device should have from the patients' perspective.

One of the problems most reported by patients is the inability to communicate properly while receiving mechanical ventilation. This incapacity to communicate conducts to unrecognized pain, feeling of loss of control, depersonalization, anxiety, fear, distress and frustration. Moreover, misinterpretation or misunderstanding of messages when nurses and patients communicate, adds more confusion to the situation.

Method

An exploratory descriptive design that involved quantitative and qualitative analysis was performed. The principal investigator, Lance Patak, interviewed each of the 29 critically ill patients using a questionnaire composed by 13 questions. For ensuring the validity of the questions, six experts that included ICU nurse specialists and nurse researchers reviewed the questionnaire. The main four questions that have driven this study were:

- How frustrated patients had been when trying to communicate during mechanical ventilation
- How frustrated patients think they would have been if they had been able to use a communication board
- How helpful patients thought a communication board would have been
- What information patients thought should be provided on a communication board and how it should be designed

Regarding the inclusion criteria, the following was established after the approval of the institution review board of an urban university medical center. Patients to be included in this study must:

- Be between 18 and 85 years old
- Speak English
- Be awake and responsive; have knowledge of the place; have knowledge of the date and situation at time of the interview
- Be competent and able to sign an informed consent form
- Have required intubation and mechanical ventilation for at least 18 hours and have been extubated within the preceding 72 hours

Procedure

The first step for recruiting patients was to ensure that each of the enrolled participants met the inclusion criteria. Next, the investigator discussed potential subject's psychological and physical status with the nursing staff to see if they have any limitation with respect of their emotional and cognitive status. After extubation, written consent was obtained from the subjects.

For the interviews, the principal investigator audio-recorded several role-playing interviews and an experienced researcher criticized these practice sessions. Afterwards, demographic data was obtained from the patients from the medical records and querying patients. The interview process lasted from 20 to 60 minutes in a private critical care room or an intermediate care room and it was audio-recorded and transcribed verbatim. All the questions were asked in the same order in all the interviews.

The 13 questions on the survey focused on three areas of interest:

- Assessing the patient's levels of frustration with communication and their perception of communicating interventions used by health care practitioners

- Identifying patient's perceived communication needs and what they perceived as barriers and facilitators to effective communication
- Retrospectively evaluating the perceived helpfulness, use and content of a communication board

From the 13 questions, 10 questions were open-ended to permit a qualitative analysis and 3 questions used 5-point Likert scale for quantitative analysis. Open questions aimed patients to describe their experience while trying to communicate, including needs, facilitators, barriers, as well as to evaluate the communication board. The other questions were intended to determine:

- The level of frustration the patients experienced
- How helpful patients thought a communication board would have been if it had been available
- How frustrated patients though they would have been if a communication board had been available

Communication Board

The communication board used for this study was the Vidatak EZ Board[27]. This communication board was developed by the principal investigator along with 4 clinical experts who were advanced practice nurses working with patients with mechanical ventilation. The Vidatak EZ Board differentiates from other communication boards in the sense that only uses alphabet letters, single words and pictures. This communication board is approximately 22 cm x 35.5 cm dry-erase board made with easer-board material in the back and the front. On the front side of the board, on the left side, a tall rectangle contains the letters of the alphabet and the numbers from 0 to 9. To the right side of the alphabet letters and numbers, a Velcro strip is placed to which a dry-erase marker is attached. To the right side, there are two boxes with the headings "I Am" and "I Want". Under each heading, the related words are listed. On the far right, topics of communications that come from "I Want" are enumerated. Below the "I Am" and "I Want" boxes, conversational phrases and questions are located. On the back side of the

board, the heading "Pain Chart" along with two images of a human body from the front and back are displayed. In the middle of these two images, a vertical scale of pain level from 0 to 10 is located. To the right side of the pain chart, descriptive expressions related to part of the human body. Lastly, on the far right, a "Memo" box for writing personal messages is located. Images from the front and back side from the Vidatak EZ Board are included below.

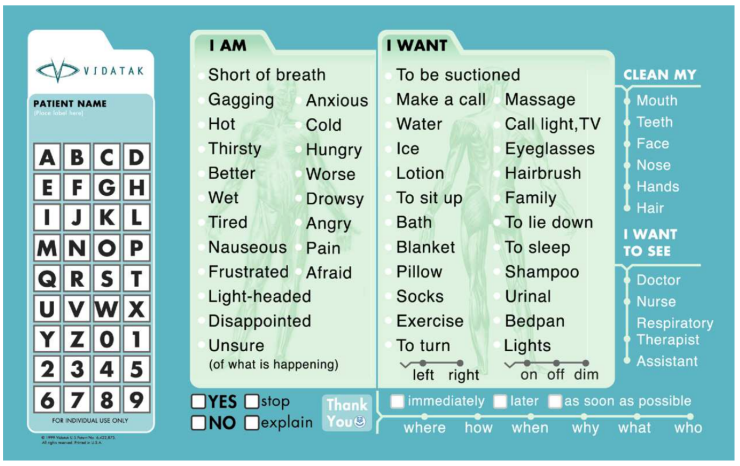

FIGURE 3.1: Vidatak EZ Board front side.

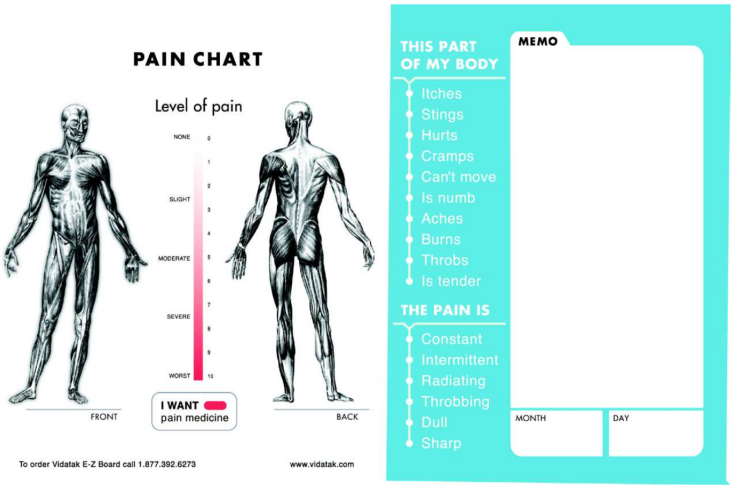

FIGURE 3.2: Vidatak EZ Board back side.

FIGURE 3.3: Vidatak EZ Board front side with pictures.

Study Results

Thirty-two patients met the inclusion criteria for the study. However, two patients were excluded, as they were too tired to complete the interview. Also, another patient was excluded from the study as the recorded interview was inaudible due to technical problems. Therefore, the remaining data from 29 subjects was analyzed.

Most of the patients were male (65.5%) and the most common diagnosis was regarding valvular disorders. The clinical characteristics of the sample included a mean duration of mechanical ventilation of 3.40 days. Most subjects (86%) had received ventilator support after receiving elective surgery. The remaining 14% required immediate intubation and ventilation due to respiratory failure.

Regarding the level of frustration, eighteen patients (62%) reported high levels associated with impossibility of communicate effectively while residing in the ICU. Seven patients (24%) described their experience as frustrating or somewhat frustrating. Only 4 patients (14%) stated that their experience during mechanical ventilation was not frustrating.

The perceived level of frustration if a communication board had been available, resulted lower (29.8%) with respect to not having it (75.8%). Forty-one percent of the patients reported that they would have not been frustrated if a communication board had been available. Around 6% of the patients stated that their level of frustration would have remained high despite using a communication board. In general, 86% of the subjects informed high frustration levels if a communication board was not available during mechanical ventilation. Only four subjects (14%) stated that their frustration level would have not changed.

With respect to patient's perceptions of the helpfulness of a communication board, sixty-nine percent reported that would have been extremely or very helpful. Eight patients, representing the 27.5% of the subjects, stated that would have been helpful or somewhat helpful. Only one subject (3.4%) indicated that the use of a communication board would have not been helpful.

As regards to patient's assessment on the content of the Vidatak EZ Board, patients provided positive and negative comments.

The following information was obtained from their suggestions and critics:

Positive Feedback:

- The communication board increased the efficiency and speed of the communication
- The communication board was fairly complete in the sense that patients found implemented most of the essential information for them
- The communication board facilitated patients' communication of their emotional needs

Negative Feedback:

- The communication board contained too much information to be processed
- The material of the communication board combined with direct light made it hard to read
- A patient stated that under his condition was unable to write using the marker, just do dots or lines

Improvement Recommendations:

- Some patients suggested implementing a more concise layout of the printed text. Also, subjects recommended changing the colors to ease the readability
- Early exposure of the communication board was recommended by patients as a way to familiarize before being in the ICU
- Patients suggested making bigger blocks for the letters
- Another advise was separating acute care needs from routine needs and stating the matter of urgency
- A few subjects suggested adding new words and phrases such as fear, gagging, chocking and "I cannot breath"
- Others requested removing words such as happy, sad, good, bad, hairbrush, water and phone

3.2.2.2 Analysis

The finding of this work provides clear evidence of the helpfulness of a communication board for patients that experience severe speech impairments. Moreover, it exposes the level of frustration that patients suffer under these critical conditions. Although, the numbers may not be representative or unbiased, they certainly give insight from the perspective of the patients.

The last part of the study assesses a communication board from the experience of subjects while residing in intensive care unit during mechanical ventilation. This part provides valuable information regarding the content and layout of a communication board. Patients' suggestions about the overwhelming layout of the text and about taking special attention to the colors of the communication board, paves part of the road towards building a tablet application without repeating the same errors. Moreover, a software application can easily face the overload of information dividing it into different virtual pages or windows. Next, the pain chart with the scale is a worthy idea where patients point approximately where the pain is and its intensity. Unfortunately, this feature is highly dependent on the precision skills of the patient. Nevertheless, it is a feature that, if the patient is able to use it reasonably well, can provide useful specific information to the doctors and nurses. Finally, the Vidatak EZ board can be used as a guide for developing a set of words and phrases where one can start to work.

3.2.3 Development of a Communication Intervention to Assist Hospitalized Suddenly Speechless Patients [12]

3.2.3.1 Summary

The paper presents a study of a multi-functional prototype communication system for hospitalized speechless patients with the aim of assessing the feasibility and usability of it. The study is guided by patients' independence to activate communication strategies that are integrated in the device and the difficulties encountered while using the device. In addition, the researchers also obtained qualifications from the participants on the importance and satisfaction when using the communication system. This speech-generation device consisted of software with pictorial hot buttons, pre-recorded messages associated with symbols, writing and typing functionalities and an urgent button. The urgent button was a separate hardware object with a recorded message for calling the nurse.

As starting point of this work, the researchers explains that healthcare staff frequently faces the challenge of taking care of patients that experience sudden speechlessness for diverse causes. Furthermore, they state that patients are challenged by communication constraints that complicate the communication with traditional methods and the lack of new communication mechanisms to express their needs. In addition, the existing non-verbal strategies for patient-nursing staff communication fails, as they are inadequate and time-consuming. Thus, the authors suggest that strategies that address communication needs should consider patients' intrinsic factors as well as the viability of application in intensive care units.

In this regard, the authors claim that there are few sophisticated tools available for speechless patients. Although sufferers have the sufficient cognitive resources, they cannot communicate due to the lack of structure or function of speech mechanisms. One of the tools used by pathologists is "alphabet boards" which is based on randomly selected pictures that are tedious to use and often restrict the construction of new expressions and urgent needs. Moreover, patients' limitations as fatigue or aftermath of a critical health event combined with flawed approaches provides evidence to identify new effective strategies that augment communication between patients and nurses.

Speech-generation devices have been accepted communication approaches in hospitalized patients by previous pilot studies that the researchers considered. However, these devices have potential to tackle intrinsic requirements as well as practicalities associated with intensive care units that need to be undertaken before incorporating them into hospital settings.

Commonly, systematic teaching strategies cannot be implemented in all cases due to the fact that speechless patients sometimes manifest unexpectedly. On the other side, patients with scheduled procedures are aware of losing the voice during the pre-operative period. As a consequence, the following characteristics were considered during the development and refinement of the speech-generation device:

- Simple implementation of a communication device that involves technology
- Easy to learn and use for both, patients and medical staff
- Effective when assistance is needed
- Meet the communication needs while the patient recovers

The following requirements were implemented as advice of the Infection, Control, Safety and Clinical Engineering Departments:

- Disinfection of each device after use of each participant
- Disposable screen protectors must be used and discarded on each device
- Extension cords are not allowed
- The device must be mounted on a mobile unit to facilitate access and use in limited areas

3.2.3.1.1 Methods

A tablet computer with an incorporated speech-generation device was used on patients in 3 adult critical care units and a medical surgical unit for a period of 10 days at most.

For the study inclusion criteria, the following were the requirements:

- Older than 21 years old
- Currently experiencing speech impairments
- No delirium as regards to the Confusion Assessment Method Shortened Version scale
- Score above 2 points in the Richmond-Agitation-Sedation scale (RASS)
- Able to read or speak English
- Participants with inability to use at least one arm are discarded
- Participants with long-term speechlessness resulting in the use of an adaptive speech-generating device were excluded.

Regarding the data collection, the following information was collected:

- Demographics
- Presence of delirium
- Agitation and sedation
- Usability of communication intervention
- Satisfaction and importance of using communication intervention

The procedure followed guaranteed that patients were not experiencing delirium and had a score of sedation based on RASS above 2 points. After ensuring this premise, each participant received a device and a short orientation on how the device works. Everyday, the research staff filled out a "Usability of Communication Intervention" form until patients were discharged. Every time that a patient needed a refresher on how the device works the information was given and noted. Before the discharge each patients filled out the "Patient Satisfaction and Usability Instrument". Regarding the data analysis, descriptive statistics on the demographics, clinical variables and scores were used. Moreover, Kappa statistic was used to test the reliability of the "Patient Satisfaction and Usability Instrument".

3.2.3.1.2 Study Results

Participants Characteristics and Ability to Activate Strategies

From a total of 24 subjects that consented to participate in the study only 11 took part. Thirteen patients were left out of the study due to the fact that they not fulfilled the inclusion criteria. The participants were mostly white males with an age range of 40 to 70 years. Around 73% of the participants were recovering from a surgery of head and neck cancer that occasioned speech impairment. The average number of days in the study was 6 days from a range of 1 to 10.

Seventy percent of the total patients in the study were able to independently activate hot buttons from day 1 after a 10 minutes review on how to use the device.

Regarding the writing and typing functions, handwriting was used 92.3% of the times and typing screen 94.4% of the times.

The urgent button was activated 83% of the times by the participants. The most common problems with this functionality were locating where the urgent button was and confusing the emergency hot button, that is provided by intensive care units, with the urgent button.

The difficulties encountered by some of the participants while using the speech-generation device were: not being able to physically push icons, the eyeglasses were not available restricting the sight, the level of sedation impaired the correct use of the device, and the handwriting was illegible. Also, some patients had trouble using the stylus to activate hot buttons due to having a pulse oximeter in the dominant hand or wrist. Additionally, re-teaching of the device use was necessary for three participants.

Understanding of Messages

Regarding the effectiveness of the communication system, 95% of the messages generated by patients were correctly understood.

Reachability of the Communication Device

During the experiment, the device was accessible to the arm's reach 96% of the times. Some of the explanations that the authors gave were the following:

- The device was moved by the nurse, physical therapy or relative and not returned to within the participant's reach
- The device was moved by the participant and relocated
- The participant requested the device to be moved
- The device was not in the room the day they were transferred

Availability of the Communication Device

The availability of the speech-generation device was evaluated by determining if it was functional when collecting information regarding the use. In this regard, the device was on and operative 68% of the times.

The following are the main reasons why the device was not functional:

- The device was powered off and unplugged for unknown issues (15.1% of the times).
- The device was not setup after it was transferred to another room (4.54% of the times)
- Participants pulled the device from the dock resulting in automatic shut-off (1.51% of the times)
- The device was moved in the room and then unplugged (3% of the times)
- The device did not produce speech (3% of the times)
- The device hot buttons were froze (3% of the times)
- The device speech and hot buttons were non functional for several reasons (1.5% of the times)

Satisfaction and Level of Importance

Participants rated the importance and satisfaction using "The Patient Satisfaction and Usability Instrument". The scale went from 1 to 5 where 1 meant strongly agree and 5 meant strongly disagree.

Regarding satisfaction, it was measured based on use of device functions, ease of device use, and ability to report symptoms and/or improve communication with nursing staff. The mean for satisfaction was approximately 1.5 denoting a high level of satisfaction.

With respect to importance, it was measured in terms of availability of the device and the importance of the device functions. The mean importance scored 1.61 implying that patients considered the use of speech-generation device and its functions of high importance.

Due to the small sample size, the kappa coefficients generated for the importance of having the device available and for ease of use are not reliable.

3.2.3.2 Analysis

The speech-generation device presented in this work consisted of four main features that, according to the patients satisfaction and level of importance, are particularly significant. The features in question were pictorial hot-action buttons, handwriting and typing functions, and an urgent button.

Patients in this study have proven that the use of hot buttons was a suitable strategy for communicating independently important issues such "Suctioning needs", "Pain intensity levels", "Breathing difficulty" and "Emergency Care". However, due to the small sample size, the precision of the study may be disputed.

In addition, according to the results presented by the authors, handwriting and typing were highly accessed. Nevertheless, specifically handwriting may be problematic as its dependent on patient's medical condition to produce legible handwriting. Consequently, it may be frustrating for patients, medical staff and families to interpret. Then, typing can produce similar outcomes to handwriting without the calligraphy issue.

The introduction of a self-contained urgent button was problematic as it was confused with the intensive care unit hot button. Hence, it might be better to incorporate it as a hot button into the device's software or leave it out of the device.

Regarding the difficulties that were faced, the most common cause for not having the device functional was because it was powered off and unplugged. This issue should be taken into account and it can be solved or minimized by instructing nurse staff to control the device periodically. Other issues such as the device being moved to another room may also be reduced using the same principle.

3.3 Augmentative and Alternative Communication for Speech Impairments

3.3.1 Wireless Communication for Speech Impaired Subjects via Portable Augmentative and Alternative System [10]

3.3.1.1 Summary

This study aimed to develop a pocket personal computer with a GSM module for implementing an AAC device with wireless communication capability for people with severe spoken communication disabilities.

The technology present in 2001 could fill some gaps that previously the communication board could not cover. Some examples of these gaps were limitation of vocabulary storage, difficulties turning the pages, lack of word prediction and lack of flexibility in the layout design. All of these represent the known drawbacks of low-tech communication boards.

Additionally, the authors stated that telephone was still the preferred choice by impaired people for voice communication over other services like e-mail, fax or voice carryover services. Moreover, as wireless technologies continued growing, these communication services could be easily adapted to people's need. Nevertheless, persons with high speech disabilities or inability to produce recognizable words are likely to have also movement deficiencies. Therefore, they came up with an AAC device with wireless communication to access information and to communicate with others.

The researchers chose the WinCE-based Pocket PC (PCC) as development platform due to the good screen resolution, the high fidelity audio and the expansion peripheral capability. The investigators considered this device superior compared to other devices. However, they remarked that the device weight was a downside, as it weighed 500g.

The design for the AAC device followed a rapid prototyping for the graphic interface and afterwards, as second phase, the implementation of the dialing functions for the wireless communication.

The software developed by the authors, offered two main functionalities: vocabulary/layout editor operated in a PC and a dynamic linkage program used in the Pocket PC. The first functionality collected used vocabularies and graphics to form a database, which was stored in the PC as well as in the Pocket PC. The software second functionality could edit the graphics in the Pocket PC allowing the users to input the vocabulary from the touchscreen. In addition, the instructors could easily access and download the database to the PC to vocabulary/layout the device. This permitted the instructors create and layout each page as well as the linkage between them using the editor. Then the resulting database could be loaded onto the device again. Lastly, a set of frequently used words during calling was also added to the database. Examples of common words used could be "I am a speech impaired person. Please be patient and listen or "This is an emergency call. I live in XX. I need help".

One of the drawbacks of this device was its reduced touchscreen size for selecting the desired vocabulary. This issue was solved using dynamic linkage between vocabularies to accelerate the communication rates. The dynamic linkage assists a user offering the most probable items based on previous use. However, in order to reduce the confusion for the user, a combination of both, dynamic linkage and semantic linkage, was implemented. The flowchart of the complete process is descripted in the **Figure 3.4**.

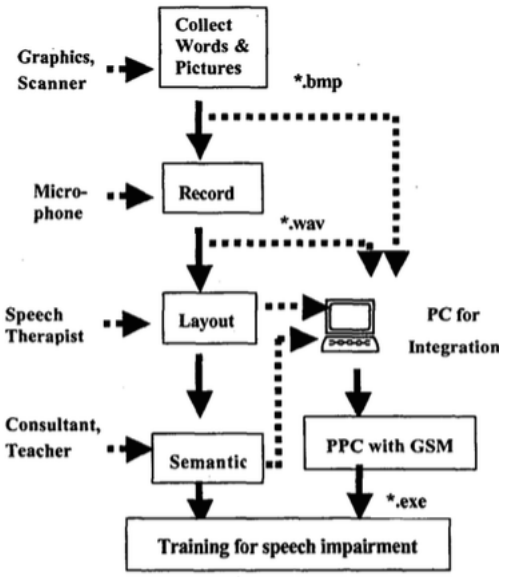

FIGURE 3.4: Flowchart for designing this AAC system

The **Figure 3.5** shows a photo of the developed PPC-based portable AAC system with GSM wireless communication.

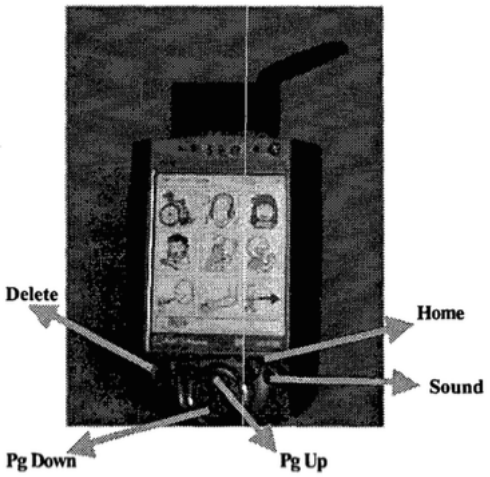

FIGURE 3.5: Photo of portable AAC implemented with a wireless module.

The hotkey buttons located at the bottom of the device were used to change the page (Page Up and Page Down), go to home page (Home) and "speak out" an entire phrase (Sound). The **Figure 3.5** displays a page with 9 icon-based phrases and at the bottom a text window is located to form the phrase. Once pushed the icon-button, the sound of the word would be generated. After completing a phrase, the user could just simply push the "Sound" button and the phrase would be pronounced.

The dynamic linkage of the AAC device was implemented in three layers: script-based linkage, category link and semantic link. The first one indicates various scenarios like school, home, shopping or telephone. In the second layer, different category fields are located such as place, people and emotions. The last layer, semantic link, is used to link vocabularies between them accelerating communication rates. For example, "beverage" page will link to "drinks" button, "place" page will be linked to "go" button and "food" page to "eat" button. Additionally, the most used elements are displayed first at the layout of the page and the least in the later pages. Regarding the telephone feature, large numerical numbers were utilized. To speed the dialing process, telephone numbers could be stored with an associated image.

As the last step of the study, the researchers gathered insights of the device using surveys from a group of children with speech impairments and stroke patients with aphasia. The

focus of the survey was on the usage frequency, the interaction between communicator and partners, and improvement in their quality life. Nevertheless, the authors have not disclosed the resulting data from the surveys. However, they foresee that the product of this study, that is, the AAC device, can be used not only at educational environments but also to be used in daily life. As a result of this, the impact would be significantly to help people with speech disorders.

3.3.1.2 Analysis

Although this application for AAC was developed time ago, its approach can be applied and updated to mobile or tablet devices with the correspondent modifications.

Word prediction feature can be used for software applications in ICU environments where patients always face communication issues, whether using paper-based alphabet board or electronic keyboards. Therefore, word prediction can highly improve patient's communication rates positively.

The navigation concept for turning pages that this paper provides using the device hotkeys could be used in a virtual manner (application buttons) if an extensive set of icons, words or phrases is used. This concept can overcome the physical size limitation in the same manner as proposed by the authors.

Finally, the researchers focused the development of the AAC device to a special group of users that have severe speech impairments. This target group did not have other problems rather than communication issues. Nevertheless, if we examine the context of use of this device in an environment like an intensive care unit, patients may have big difficulties using the telephone capability provided by the GSM module. These difficulties rely on the medical condition that the sufferer has while residing in the ICU. For instance, a patient with an endotracheal intubation or tracheostomy may not use the telephone capability. However, he could benefit from the vocabulary and graphics that the device offers to communicate.

3.3.2 A Phonology-free Mobile Communication App [14]

3.3.2.1 Summary

The research paper presents the design of a phonology-free mobile communication application for patients with aphasia or other communication disorders.

People that suffer from aphasia have normal cognitive functions in everyday activities that do not involve speech communication. For example, patients can use the public transport without problems, as they do not need to communicate with anybody. However, aphasic patients may experience difficulties to manifest their emotions, feelings or wants. For example, in a chess game between aphasic patient and his opponent, the first may feel upset when he sees that his opponent performed an illegal intentional movement and not being able to communicate with the referee.

Application Design

Regarding the application design, it is based on visual "boxes". Each of them represents different functionalities that the application provides. The first screen that is displayed when the application is launched is the home screen (**Figure 3.6**). The home screen is made of a grid where each of the available options is exposed with high contrast to aids the visualization.

One of the features that from the authors' point of view differentiate this application from the rest is the food and shopping boxes. These boxes call Google Images as a subroutine to expose a huge number of images available on Internet to minimize the number of original icons needed. The patient can save the desired image into a folder with the thumbnail of its box of origin for later use. Moreover, patients can take photos using the in-app camera box to save important people, places or objects into a favorite folder to have them as fast access (**Figure 3.7**).

Aphasic patients have needs and wants that can also be non-material such as the desire to relax or to accurately express an emotional reaction. Therefore, the authors included a specific box for engaging relaxation and hobbies. This box presents icons related to these

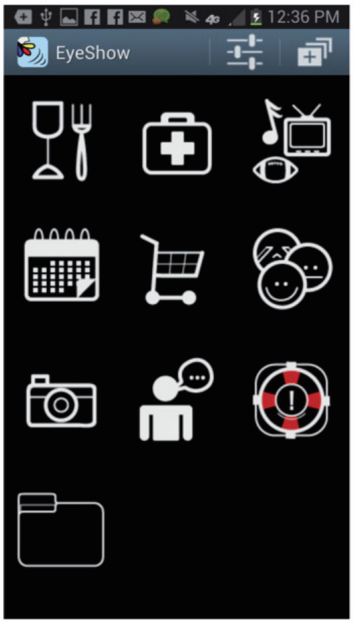

FIGURE 3.6: Application Home screen displaying all the available options.

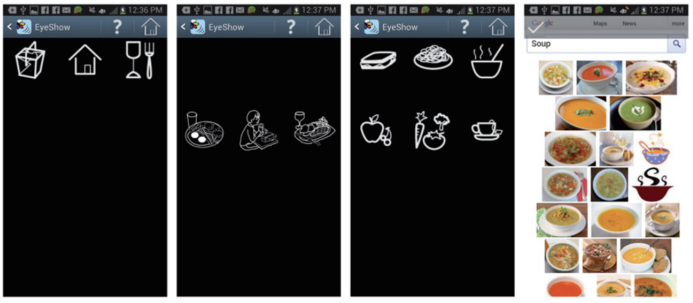

FIGURE 3.7: Expression of user's material wishes, needs and desires through selection of visual inputs.

activities such as sleeping, playing a specific sport and listening music. The **Figure 3.8** illustrates this functionality.

The emotion box included in the application provides a non-verbal pictorial system to communicate feelings with a slide bar to accurately quantify inputs and translate them into phonological output.

Another box included in the application is conversational phrases. This feature has common phrases such as "thank you", "congratulations", "how are you?" which are not easily depicted with icons. Thus, they are presented using video loops.

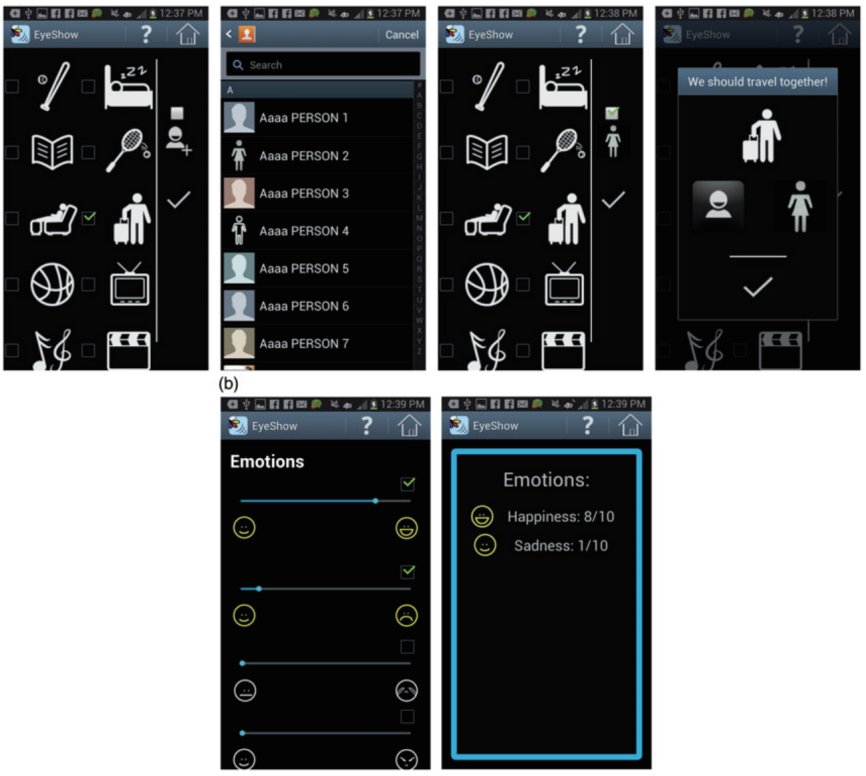

FIGURE 3.8: Conveying non-material desires and response with Entertainment box and Emotions box.

Next, a special box for medical purposes was added to the application. This box records medical information related to the patient like history of present illness, current medication, past surgeries and allergies. The caretaker or family members should be in charge of adding this information as the patient is not able to do it.

Also, a calendar box was provided as a way to record appointments and custom events such as medication reminders without the need of words.

In emergency situations, aphasic patients cannot perform well due to the lack of phonology. Therefore, the authors provided a help box to solve this issue. The user can program the application to shout "help" or any other message as well as to perform a phone call to a specific contact. Additionally, the authors included short tutorials for each box as well as for the navigation and output menus.

Usability Testing of the Application

The authors tested the application with only one patient that suffered from Broca's aphasia with preserved repetition. After minimal instruction, the patient was able to navigate and interact with the application. The patient's family, the patient and the nurse related to the patient found the application very helpful for improving the communication. However, the authors remarked that further and more formal studies should be conducted in order to validate their findings.

3.3.2.2 Analysis

Despite the fact that the mobile communication application aims to aphasic patients, some ideas from the approach followed can be used.

First, the application design based on grids and icons seems to be helpful to expose the available functionality for patients with communicate disorders. This approach is similar to what was found in several applications specifically designed for augmentative and alternative communication. Despite the fact that the patient that tested the application learned how to use it with minimal effort, the validation of the usability tests can be highly questioned. As stated by the authors, more research on their findings with a bigger sample should be done in order to ensure that the application fulfills the patients' requirements.

Next, in an intensive care unit environment, a non-verbal pictorial system to communicate feelings and wants can be quite useful as several patients have their cognitive skills diminished. Nevertheless, the interface element implemented by the authors can be problematic. Patients in ICUs generally do not have great precision skills, so a slider interface object will probably make things even worst with the device. Consequently, the communication can be affected negatively rather than improved.

Finally, the authors proposed a solution for the problem of expressing emotional needs that is interesting. The solution involves selecting the current mood from a predefined set of options. This approach is quite similar to "Wong-Baker Faces Pain Scale". Nevertheless, in order to be applied this approach needs a slightly modification. An alternative from

their idea would be using more options in the form of pictures or boxes to diminish the possible motor skills difficulties that patients under critical conditions have.

3.3.3 Augmentative and Alternative Communication: Vox4All [9]

3.3.3.1 Summary

Quintela et al. proposed Vox4All, a tool for tablets and smartphones that provides a system of augmentative and alternative communication to minimize or overcome sensorial, cognitive or motor deficit, with diseases, disorders or other limitations that compromise the ability to communicate. In this regard, the end users of the system, as they are quite diverse, the researchers considered distinct degrees of disabilities and ages, to provide access accordingly to the skills and communicative needs.

Before the development of this tool, the researchers performed a structured research work to evaluate its relevance and identify which main features should be considered with the objective of publishing the product in the market. Several applications for augmentative and alternative communication were analyzed and reviewed. From a set of 40 applications for iOS or Android operative systems, 8 were selected as they "gather a larger number of features, best practices and a higher level of innovation". Afterwards, a survey was performed to comprehend the needs and expectations of the public aiming to develop a solution in the field of AAC. This survey was planned to gather insights from rehabilitation therapists, speech therapists, occupational therapists, special education teachers, psychologists and rehabilitation engineers. Lastly, they gathered end user feedback using questionnaires and data from direct observation as part of the design.

Regarding the implementation, Vox4all is based on the principle of communication grids with symbols from a predefined pictographic system. This system allows users with communication impairments to express themselves, demonstrating their opinions, wishes, feelings and decisions. Therefore, in order to improve the expressiveness of the users, the researchers added voice output and message recording.

The researchers stated that when analyzing the results of the survey, only 37 out of 300 were answered. Additionally, the respondent's age varied in the range of 25 to 54 years with different professional experience. In regards to the symbol system, participants considered Picture Communication System as the most complete followed by Widgit Literacy Symbols. Respondents also reported some characteristics as highly desirable such as compatible with different ages, write text for use of speech synthesis, ability

to import images, word prediction, autonomy, portability and touch screen-enabled. On the other side, the organization of communication grids was the characteristic less satisfying. When asked about restricting the "traditional board" only for mobile phones, none of them have considered it as advantageous. Lastly, about 67% believed that the implementation should be available in both platforms: mobile phones and tablets.

3.3.3.2 Analysis

The information provided by the researchers is quite useful as they expose a collection of core characteristics that from their judgment consider fundamental for developing a competitive application in the AAC market. This core can be used as starting point for developing an application for ICU environments.

Furthermore, the authors remarked that the Picture Communication System was considered as the most complete by the people surveyed. This fact is consistent and apparently is what a number of software applications for AAC such as Proloquo2Go [16], AugieAAC [17], ICommunicate [18] and Look2learn-AAC [19] to name just a few, tend to implement.

This application provides a high customization of the interface as well as the content. This seems to be helpful to focus the application to different target users. In the case of ICU patients, this can be helpful as the needs of them are not the same as for a child with autism or other special needs.

Although the main features seem to be quite complete for an AAC application, some of them may be unnecessary in intensive care unit environments. For example, the food option in the application displays several elements that the user may wish to eat. Patients are not allowed to eat what they want due to being under strict medical control or simply because their medical condition, such as a tracheostomy procedure or mechanical intubation, does not permits it. Another example can be seen in the "I want" option. This option, offers alternatives that are not suitable for patients like as "do sports", "watch TV", "call" or "dance".

3.4 General Design Recommendations for Older Adults

3.4.1 Design and Evaluation of a Mobile User Interface for Older Adults: Navigation, Interaction and Visual Recommendations [13]

3.4.1.1 Summary

The paper describes the design and usability process for a user interface of a smartphone application designed to promote exercise and improve equilibrium among older adults. The work was carried out in three successive iterations with different groups of older adults.

One of the serious concerns that older adults have is equilibrium. As people age, they start to show lower physical activities and logical changes in the postural stability. Consequently, the authors of this paper proposed a smartphone application in the form of a dance game to assess the risk of losing the balance and, in the same way, promote physical activity.

3.4.1.1.1 Application Description

The application, developed by Fraunhofer AICOS in Windows Phone 7, uses the smartphone sensors to measure the user performance to assess the risk of falling. The user attaches the smartphone to his lower back while he dances following dance steps from a Google TV. The smartphone's sensors collect information regarding accuracy, timing, stability and grooviness. Then, the risk of falling is assessed based on the quality of the user locomotion and a supplemented brief clinical questionnaire.

3.4.1.1.2 Methodology

The test place took place at a care center were participants were recruited. Each test lasted 20 minutes with the supervision of two researchers. The sessions were divided into introduction, teaching and training vertical and horizontal swipes, tasks, user satisfaction

questionnaires and debriefings. All sessions were video recorded and afterwards analyzed. For each participant the following information was evaluated:

- Task Completion
- Task Completion Time
- Number of Errors per Task
- Time Necessary to Recover from Error
- Notes and Comments for Qualitative Analyses
- Answers from User Satisfaction Questionnaire

3.4.1.1.2.1 Session 1

A total of 9 participants with an age range between 65 and 92 were divided into 2 groups. Each group tested one of the two application prototypes presented in the session. The first prototype implemented "Panorama Control" design and the second implemented "Panorama along with Pivot Controls" design [23].

3.4.1.1.2.2 Findings from Session 1

The first session yielded negative outcomes regarding the designs. First, seniors had difficulties understanding the navigation concept concerning organization and hierarchy. Furthermore, the swipe movement to change the layers that compose Panorama design was unclear for them. Next, Pivot Controls are displayed as partially hidden headings with the purpose of suggesting that more options are available [24]. These elements were not perceived as actionable and nor as swipeable to reveal new content. Then, older adults exposed that the contrast between headings was not appropriated for them obfuscating the readability. Finally, researchers noticed that participants tended to press icons rather than the text associated to icons. This situation was problematic since WP7 relies heavily on text as buttons.

3.4.1.1.2.3 Session 2

For this session, 9 new participants were recruited with an age range between 68 and 89. In this time, participants tested the new design of the user interface based on the findings from session 1. The objective of this session was to assess the new interface, which was based on a home screen that exposed the main options available. The tests were aimed to evaluate system structure, ease of interaction, wording choices and text input.

3.4.1.1.2.4 Findings from Session 2

First, the home screen concept was better comprehended by participants. They were able to navigate through the application hierarchy moving back and forward without problems. Next, participants had difficulties using the virtual keyword, as it followed the "QWERTY layout" and not the alphabetic order which some of them expected. In the same line, font size was not confortable due to the reduced size. Moreover, the size of keyboard keys was too small. Participants were prone to typing errors when they tried to select the appropriate key. Lastly, some words used in the application did not match into older adults semantic field around "dancing". Examples of this were dancing against someone or dancing to play a game.

3.4.1.1.2.5 Session 3

The last session was conducted with 7 older adults, with an age range between 65 and 96. The session's objective was to evaluate the changes performed to the interface as a result of the findings from session 2 but also assessing the semantic analysis of the words used in the interface, the intelligibility of icons and the ease of use of Windows Phone List Pickers.

3.4.1.1.2.6 Findings from Session 3

To start with, seniors had trouble associating gestures with different tasks such as tap for

actionable buttons or swipe for scrolling lists. Also, they were unfamiliar with the concept of navigation back to the main menu, entering certain section or second navigation level. Next, Windows Phone List Pickers were hard to use without the assistance of the researchers. In fact, researchers remarked that this issue could be as a consequence of list pickers do not have arrow indicators or any aid that indicates that the element should be pressed. Following, participants assimilated the back button as a fail safe mechanism. Older adults rely on it every time they do not know how to solve a specific problem or difficulty. Finally, a demonstration on how gestures works for Windows Phone was needed since the interface does not clearly exposes the available gestures and therefore older adults were not aware how to manipulate the interface.

3.4.1.1.3 Recommendations

The authors summarized their findings into 3 different categories: Navigation, Interaction and Visual Design.

Navigation

• Panorama and Pivot Control should not be used for designing for older adults. Their mental model simply not suits with the organization and hierarchy of these designs.

• Home screen menu, like a table of contents with all the application main categories, aids users to understand the hierarchy and the system structure.

Interaction

• A back button performs as fail safe mechanism so older adults can use it when they do not know how to solve a specific problem.

• Older adults are not aware beforehand of using the swipe gesture to scroll content. However, if seniors are taught how it works, they can navigate the application without major problems.

• The use of virtual keyboard should be minimized. Older adults often found difficult to use it and in general, it is an activity prone to errors.

• The terms used in the application should suit older adults' semantic field.

Visual Design

- Spacing between items should be generous to avoid accidental presses.
- Buttons should be designed as icons with text.
- Avoid positioning elements toward the edge of the screen.

3.4.1.2 Analysis

The authors' recommendations can aid to avoid some issues they had while performing their usability studies. First, regarding the navigation, Panorama and Pivot Controls does not seems a reasonable choice for Intensive Care Unit environments as it will probably not suit patients mental model. However, home screen menu seems to be a more appropriate approach as the results reported by the researchers exposed less time spent to complete tasks. With respect to, back button, as suggested by the researchers, it can be a valuable mechanism to let patients have the control of the situation if they are not able to interact as they expect. Following, using gestures as scrolling or swipe might be problematic for patients as their condition may limit hands movement and, in this way, it can produce frustration, lack of interest or other adverse effects that affect the patient's communication.

A virtual keyboard, as suggested by the authors, is a characteristic that should be minimized for elderly. However, in order to expand language impaired people's power of expressiveness, communication boards with printed alphabet letters are often found as an AAC tool. Therefore, providing a virtual keyboard within a tablet application can be beneficial for ICU patients. Regarding the vocabulary involved in the application as remarked by the authors, this should be a major concern in an application for ICU environments. Patients usually have their cognitive, motor and sensory skills diminished. Hence, ambiguous terms or uncommon vocabulary for them can compromise the communication with family members as well as medical staff.

Lastly, from the visual design recommendations, extra spacing between elements and buttons with icons and text seems to be appropriate. Nevertheless, instead of providing extra spacing a different approach could be applied. For instance, the size of buttons could be increased to avoid accidental presses. The drawback of the latter is that the available physical size will be dramatically reduced as the size of buttons is increased. Regarding icon and text as buttons, this approach eases the interaction with the application

as older adults tend to think that an icon is a button and pure text not. Unifying them in a single element can reduce errors and fits better seniors mental model of buttons. Additionally, some icons without text can be ambiguous to interpret, especially those related to navigation. This ambiguity can be overcome providing the corresponding text always with the icon. Therefore, elderly patients in intensive care units can benefit from this approach.

3.5 Conclusions from the Bibliographic Research

As a summary of the literature review, the **Figure 3.9** presents the summary of the works analyzed above in this chapter.

- The column “Type” details if the work analyzed corresponds to a model, a research or a software application
- The column ”Intended User Population” refers to the end user that the work focuses on
- The column “Suitable for Non-programmed Interventions” refers to the case that if patient is admitted to the intensive care unit unexpectedly, if he will be able to use the method or tool or not
- The column “Allows Reduced Mobility” indicates if the method or tool could be used by patients with reduced mobility
- The column “Usability Evaluations” details the evaluation method performed by the authors to assess the method or tool with regards to usability or user experience
- The column “Sample Size” specifies the number of participants that took part of the “Usability Evaluations”
- The column “Technology Employed” refers to the technology involved in the method or tool. It can take the following values: low, medium or high technology

	Type	Intended User Population	Suitable for Non-programmed Interventions	Allows reduced mobility users	Usability Evaluations	Sample Size	Technology Employed
The Children's Hospital Boston Model	model	Pedriatic ICU Patients	No	Yes	informal interviews	<2000	low, mid and high technology
Communication Boards in Critical Care: Patient's View	research	ICU Patients	NA	No	structured interviews	29	low technology
Development of a Communication Intervention to Assist Hospitalized Suddenly Speechless Patients	software application	ICU Patients	Partially	Yes	informal usability evaluation, satisfaction questionnaires	11	high technology
Wireless Communication for Speech Impaired Subjects via Portable Augmentative and Alternative System	software application	People with severe spoken communication disabilities	Yes	No	surveys	Not Disclosed	high technology
A Phonology-free Mobile Communication App	software application	Pacients with aphasia and other communication disorders	Yes	No	informal usability evaluation	1	high technology
Augmentative and Alternative Communication: Vox4All	software application	People with different communication disabilities	Yes	No	surveys	37	high technology

FIGURE 3.9: Summary of the Literature Review.

The big majority of the proposals analyzed employed high technology, as most of them are software solutions in a dedicated device. Particularly, the Children's Hospital Boston Model has a dedicated phase to introduce different communication tools with distinct technology levels. These tools vary from low technology tools such as pen and paper, to high-technology tools like Speech Generation Devices.

The validation of all the proposals can be questioned, as the combination of the usability evaluations performed with the sample size shows that there is no perfect balance.

None of them have performed formal usability evaluations more than by means of interviews and surveys. Although two of them have conducted informal usability evaluation, no reports or details that reflect how they were planned or executed. This is clearly a downside in all of the studies analyzed in this chapter.

The sample size of each proposal examined varies considerably. When we analyze this attribute combined with the usability test employed, we find that only two informal usability evaluations were performed. Particularly, one of them with a small sample size. Conversely, with a sample size bigger than 11, we can see a big predominance of surveys and interviews as usability test used. Interestingly, The Children's Hospital Boston Model has the biggest sample size but with an informal approach for usability evaluation.

All of the works analyzed were aimed to people with speech limitations. However, only the first three were only focused on intensive care unit patients. The other ones were oriented to people that suffer communication disabilities but in different contexts with regards to intensive care units.

In this regard, the applicability to ICU's of the tools or methods that might result from the works analyzed depends of each case. ICU patients are usually reduced in their mobility. Therefore, most of these methods or tools are not suitable to people with this kind of restraints, as they might not be able to use them efficiently due to not being designed for that context.

ICU patients are not always admitted to the intensive care unit as a result of a scheduled medical procedure. As seen in the **Figure 3.9**, some of methods or tools are suitable

to non-programmed procedures. However, those that are suitable do not allow reduced mobility.

As a conclusion to the information analyzed in the **Figure 3.9**, we can say that none of the proposals fulfills all the attributes that we consider necessary:

- Intended for intensive care unit patients with speech impairments
- Suitable for non-programmed interventions
- That allows reduced mobility users
- With formal usability evaluations

Chapter 4

Qualitative Analysis: Design & Execution

4.1 Introduction

To be able to perform this qualitative analysis, it was of vital importance to count with a doctor from an intensive care unit department. Hence, a doctor from the Hospital Universitario de la Princesa took part in this research with the role of coordinator. This link between the university and the hospital has provided us with the expertise and problem resolution capacity in ICU environments that our background in computer science does not provide. In addition, this connection has allowed us to clarify any doubt or to explain the medical protocols followed in the healthcare field. Furthermore, the doctor was the only one who has the ability to recruit actual participants with different profiles, but all of them involved in an ICU environment such as patients, medical staff and patient's relatives. Naturally, the presence of this coordinator was fundamental to plan and execute a research of these characteristics.

4.2 Profile Identification

The first step in the research was to identify the profiles that are potentially related in some way to an intensive care unit environment. After performing a brainstorming

session with the hospital coordinator, three main profiles were recognized:

- Patient
- Patient relative
- Hospital staff-member

The patient profile has intrinsic characteristics that make it a heterogeneous complex group. In order to have better and deeper understanding of this group and, at the same time, to build a wider perspective, it was divided into two sub-profiles. The sub-profiles obtained were the following:

- Patient with intubation
- Patient with tracheostomy

These sub-profiles gave more information that differentiates patients from the same group from a speech impairment perspective. However, as this division was still quite broad, another refinement iteration was carried out. Particularly, patients either with intubation or with tracheostomy, can have or not neurological disorders. Therefore, the hierarchy obtained was the following:

- Cognitive disorder
- Motor disorder

This division was strongly suggested by the hospital coordinator as both may have communication problems but its medical nature is quite different.

Next, the patient relative profile was split into: close relative and non-close relative. Mainly, it was necessary to be able to distinguish those who can add information in a meaningful way from those who cannot. Among the first ones, both biological relatives and those related through marriage are included, while in the second group are included the rest of interpersonal relationships.

Lastly, the hospital staff member profile represents the distinct members who work or are related in some way with patients in the intensive care unit. Hence, the following sub-profiles arose:

- Doctor
- Nurse
- Nursing Assistant
- Physiotherapist
- Hospital Housekeeper

The **Figures 4.1**, **4.2** and **4.3** summarize the hierarchy of the profiles determined.

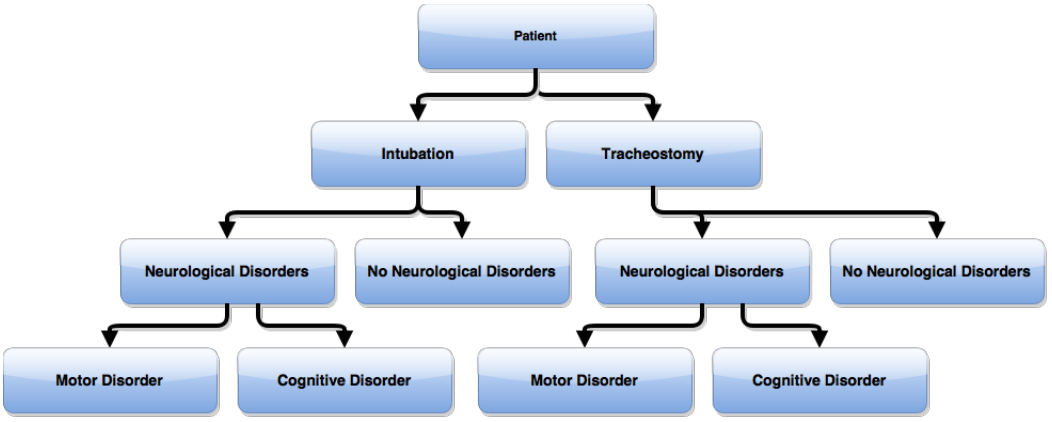

FIGURE 4.1: Patient Profile Hierarchy.

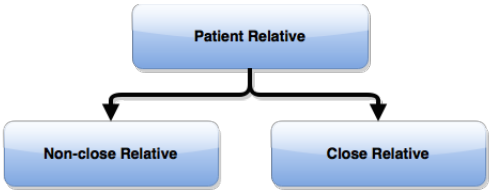

FIGURE 4.2: Patient Relative Profile Hierarchy.

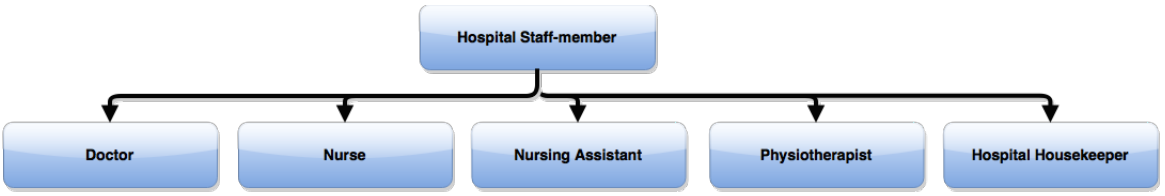

FIGURE 4.3: Hostpital Staff Profile Hierarchy.

From the profiles identified before, only a subset was used for this study. The main reason behind this decision relied on the complexity of considering in a first prototype all the existent profiles. Therefore, the selected profiles for this study were:

- Patient with intubation
- Patient close relative
- Doctor
- Nurse
- Nursing Assistant
- Hospital Housekeeper

4.3 Selection Criteria

Once the authorities of the Hospital Universitario de la Princesa consented to run this study, the hospital coordinator recruited the participants for the interviews. Three different selection criteria, according to the profiles defined in **Section 4.2**, were followed to be able to participate in this study: patient selection criteria, hospital staff selection criteria and patient relative selection criteria.

Patients Selection Criteria

- Spanish-speaking
- Be able to understand and comprehend an informed consent form
- Be able to sign the informed consent or have a legal tutor able to sign it

- Be part of one of the profiles before defined
- Have been intubated without neurological disorders for at least 24 hours without or with low sedation
- Be able to recall at least part of the stay in the UCI

Patients Relative Selection Criteria

- Spanish-speaking
- Be able to understand and comprehend an informed consent form
- Be able to sign the informed consent
- Be part of one of the profiles before defined
- Be a close relative of a patient
- The patient of whom he/she is relative has to be part of one of the profiles described above

Hospital Staff Selection Criteria

- Spanish-speaking
- Be able to understand and comprehend an informed consent form
- Be able to sign the informed consent
- Be part of one of the profiles before defined
- Has worked for at least 1 year in the ICU

4.4 Participants and Interview Questions

After the selection process, 12 subjects from the preceding profiles were interviewed by one of the authors of this study. From these, 7 were from the hospital staff profile, 3 were from the patient relative profile and 2 from the patient profile.

Previous to the interview process, a set of questions was elaborated to guide the interview procedure. These questions were aimed to understand needs, wishes and experiences of all the individuals intervening in an intensive care unit, but especially of the patients that have to reside in it.

4.5 Interview Execution

All the interviews were performed in the hospital facilities. The time and date for each meeting was individually arranged with each of the interviewees by the hospital coordinator or in some cases, by the researcher who performed all the interviews.

The hospital staff members were interviewed in the intensive care unit into two different rooms assigned for meetings purposes. At the time of the interview, the first available room was chosen to perform the interview. Furthermore, the interviews were executed with the door closed to minimize most of the noises of the ICU and to ensure the privacy of the respondents.

The interviews with patients were conducted in medical rooms where they remain once they leave the ICU until they are fully recovered. Despite the fact that these rooms are usually shared with other patients, the interviews were performed there for an important reason. Principally, we think that patients should always be comfortable with the environment. Additionally, we intended to avoid making them move to another place, as it can be complicated depending on each patient's medical condition.

With respect to the relatives of the patients, these interviews were performed in a private meeting room in the same floor as the ones where medical rooms are located. Similarly to the ICU meeting rooms, these interviews were performed privately with the door closed and with low environmental noise.

A semi-structured interview was selected as research method, as it allows participants to express themselves openly without following a strict order of the planned questions. Additionally, this type of interview allows to adapt accordingly to flow of the interview, adding or removing question if the interviewer considers it necessary.

The process for each interview followed the same steps. First, a short introduction about the research, the objectives and the procedure was explained to the participant. Then, after the interviewer answered all the questions that the participant could have, an informed consent was read aloud and explained to him. In addition, the participant was informed that the interview was going to be recorded. The benefit of recording the audio of each interview, is that allows the interviewer to observe the participant's body language and to take field notes that could provide extra information to understand some responses. Once the participant read and signed the informed consent, the interviewee filled a short questionnaire about the participant personal details. This questionnaire was different depending on the profile that the participant belonged. The objective of these questionnaires was to obtain demographic information from the participants. After completing the questionnaire, the interview started. The entire session was audio recorded with a mobile phone. The session was guided by the set of questions that was prepared before starting the interview process. Lastly, once finished the interview, the participation of the interviewees was acknowledged.

The questions used during the interviews, personal questionnaires and informed consent are included in **Appendix A**, **B** and **C** respectively of this document.

Chapter 5

Qualitative Analysis: Results

5.1 Intensive Care Unit Environment

When the patient wakes up for the first time in the ICU, he becomes very nervous. Nurses always try to calm him down with the sight on their eyes and then, they explain the situation and why he is there. Most of the times, patients are tied to the bed so that while sleeping or being extremely agitated they do not extubate themselves or unplug cables. As explained by a nursing assistant, "if I were admitted in the intensive care unit I would feel terrible". She continued explaining that the lights are always switched on and the hospital staff discuss loudly about medical issues next to the patients very early in the morning. This makes the patients lose the perception of the course of time, which alters how they rest.

5.2 Type of Communication with Respect to the Patient's Profile

In the intensive care unit, the patients that reside are not all of the same kind. According to one of the subjects interviewed, to be able to understand how patients communicate, one need first to differentiate from patient to patient because the medical conditions for each are not the same. Firstly, patients with no speech impairments that do not suffer neurological disorders and do not have intubation or tracheostomization communicate

without issues as they use verbal speech to express themselves. Secondly, patients with endotracheal intubation with no neurological disorders generally communicate properly and the medical staff understands their messages without major issues. Thirdly, patients with endotracheal intubation that are agitated at the same time with neurological disorders present difficulties to communicate properly. Next, patients with neurological disorders, with or without endotracheal intubation, have several difficulties to express themselves. Additionally, the type and degree of disorder negatively impacts the communication means. Lastly, there is a special type of patients, the elderly ones. This is one of the types that have more troubles to communicate like the previous type, as the adaptability and learnability is very limited.

5.3 Communication Methods and Tools

The methods or tools that patients utilize to communicate does not follow a specific protocol or guide and, in general, depend on their medical condition.

A nursing assistant declared that patients always try to speak, despite having an endotracheal tube or other speech impairment. The patients with no speech impairments and without tubes simply use verbal communication, as they do not have issues to interact with other people. On the other side, the patients with a reasonable level of consciousness with speech limitations do not produce audible speech. In these situations, the medical staff tries to read their lips to understand the conveyed message.

Speech impaired patients usually make hand gestures to point objects or body parts. In this regard, a patient interviewed commented that every time she was thirsty or wanted to urinate, she finger-pointed at her mouth or groin.

Sometimes, sufferers use pen and paper to write phrases or words, if the medical condition permits it. Several interviewees stated that most of the patients, due to their muscle weakness, are not able to use this method successfully. Muscle weakness or edematization of body parts often occurs as result of long stays in the ICU or as a consequence of a surgery. Hence, patients with prolonged stay tend to suffer these symptoms and as a result, they are not able to use properly the available tools, especially those that require precision.

Other times, a "communication board" made of cardboard with big printed alphabet letters is used. In order to use this board, the user points with the finger each letter and the receiver writes down the letter to build words and phrases. The drawback of this tool is that requires a great effort and a lot of time for the patients to be able to build messages. Generally, patients end up frustrated, tired and avoid using this tool.

One of the interviewed nurses commented that once a foreign person was admitted in the ICU and to his bad luck, was unable to understand the language of the local environment. The method that the hospital staff came up with was to use paper printed questions in the patient's language. The nurses displayed the questions and the responses were in the form of the patient head gestures.

When doctors or nurses want to communicate with a patient, they often perform "Yes-No Questions". Depending on their capabilities to answer these questions, patients usually employ eye gestures, head gestures, hand gestures or answer yes or no by squeezing a nurse's hand.

With regards to the content of these questions, there is not a formal elaboration procedure. In fact, according to a doctor "in college you do not learn how to make these questions. The experience from the intensive care unit is everything you have".

According to the interviewed hospital staff the most common questions performed in the ICU are the following:

- Do you have pain?
- Do you feel sick?
- Are you uncomfortable?
- Are you nervous?
- Are you hot?
- Are you cold?
- Are you hungry?
- Are you thirsty?
- Do you want another pillow?

- Does it itch you there?
- Do you want to urinate?

The previous methods or tools do not always work with patients with neurological disorders. The communication with this type of patients is quite problematic and sometimes to be able to understand the feelings or expressions the nurses or doctors read the medical monitors. For instance, if a patient has an episode of hypertension or tachycardia that does not follow a clear medical reason, it is probable that the patient wants to communicate an issue and he is not able to do it.

Despite the fact that these methods or tools slightly satisfy the problematic communication of patients, all the participants in the interviews firmly stated that they are not adequate. The most highlighted issue was the inaccuracy that these tools have to express what the patients need, want or wish. Particularly, the daughter of a patient stated that these tools and methods are not enough. Also, she affirmed, that "patients spend a lot of time in the ICU, it must be maddening to try to say or explain what they are experimenting and not being able to do it". In the same regard, a nursing assistant explained that these methods or tools are what they have to cope with communication daily, since there is no other choice.

5.4 Communication Between Peers

The patient's communication to his relatives is not the same as with the hospital staff.

As reported by a hospital employee, the doctor-patient communication is the minimum necessary. In this sense, she declared that the doctor's main objective is the patient's health. Regarding the same topic, a patient expressed that, as she was unable to communicate properly, the communication was almost inexistent with the people who worked in the ICU.

On the other side, relatives are the ones who spend most of the time trying to understand the patient messages. Consequently, they are also the ones who communicate the most with the patient.

A nursing assistant expressed that from her experience in the ICU, she saw that if a patient is very close to his relatives, then, the positive influence is manifested in the will to communicate with them. Conversely, if a patient does not have a strong bond or simply does not want to communicate with his relative, the communication with them is almost non-existent.

5.5 Common Needs and Emotions Manifested by Patients

Regarding the most common needs manifested by patients, the following list summarizes the participants' observations:

- Discomfort
- Suffocation
- Pain, due to the body position, a specific area or inflicted by the endotracheal tube
- Feeling sick
- Physiological needs
- Fear about being in the ICU
- Need to be sit on or get out of the bed
- Need to see his/her family

Given the situation that patients experience when they are admitted in the ICU, most of their feelings and emotions are negative and pessimistic. While inhabiting in the intensive care unit, patients generally feel depressed, unhappy, abandoned and diminished.

Most of the patients at first are scared, noted a hospital employee. Once they become aware of their illness, they get really sad and other times really furious with themselves. With respect to patients with neurological issues, at the beginning, most of the time they are not aware of their situation. Then, as they recover their state of lucidity, they get depressed.

One of the interviewed nurses stated that patients have a lot of ups and downs in their emotional state. The longer the patient stays in the ICU the worst he will feel

emotionally, which usually leads to the use of antidepressant medication. In addition, nurses have to repeat the same questions more than once because they do not understand the patient's response. Then, if the patient has a good emotional state, the communication tends to be "easier" as he remains calm and tries to cooperate. On the contrary, if the patient feels depressed or unhappy, he loses the patience quickly and becomes desperate easily.

A patient relative, trying to explain what her mother experienced, commented that she was always desperate and anguished as she was not able to interact using hand gestures. In the same sense, a patient explained that because she did not have any tool or method to communicate she felt "very bad" and isolated.

According to an ICU professional, young patients tend to assimilate it worse compared to elderly. If an elderly patient is admitted in the ICU he usually is less conscious of his situation because of the sedation level or because he was admitted as part of a scheduled surgery. In the latter case, the sufferer knows that if the medical evolution is satisfactory, in a short time he will leave the ICU with a better quality of life than he had before.

Finally, a nursing assistant pointed out that patients feel overwhelmed with many unfamiliar people working around them and generally, they feel unprotected both in the personal and in the physical aspects.

5.6 Urgent Communication

At the moment of expressing urgent messages, a patient is not always able to do it. Mainly this is due to the fact that, in some cases, the tools or methods at his disposal do not have the capability to fulfill this requirement. Under these circumstances, the subjects address this situation differently.

A patient relative commented that her mother was unable to communicate in the case she had an emergency. The daughter angrily remarked that her mother used to wait until visiting hours to express any message being urgent or not, as the hospital staff did not dedicate much time to comprehend her messages.

Several interviewees exposed an interesting situation. Patients in the ICU do not have attached to their beds a nurse call button like low-risk patients in medical rooms. In those rooms, this button is used to call for assistance or to indicate that a problem may have happened. However, in the intensive care unit patients are not allowed to have a call button like that. When consulted about the reasons, an ICU professional answered that this button is not necessary as patient are under vigilance 24 hours a day. Also, they commented that if patients had a button of such characteristics, the noise that it would generate could interfere with the sound alerts that medical monitors emit, as well as it could confuse the nurses with unfamiliar sounds.

According to one of the interviewed patients, her method for calling for help consisted raising the arm. However, she stated with resignation that this method was ineffective because the nurse was always busy with other patients and she had to wait to be seen to be assisted.

In a desperate attempt to call for attention, some sufferers find their way hitting the bed rails to make some noise. Although this method fulfilled their purpose, it is not adequate for all patients as some of them have muscular weakness or cognitive disorders.

Another method used by ICU patients to attract attention was explained by a nursing assistant. She told that in some occasions, if the sufferer is not sedated, he detaches himself the "pulse oximetry" from his finger, as this device is used for monitoring the patient's oxygen saturation and when detached from his finger it cause that the medical monitors start to emit sound alerts. Then, because of the sound alerts, nurses go to check if there is a problem with the patient.

Other hospital employees commented that if patients appear to be visibly desperate because they are not able to communicate, then, nurses check if there is an emergency or something that they wish to communicate.

One of the interviewed nurses expressed that the impossibility to communicate urgent issues has negative effects on the patient's health. To illustrate his point, the hospital employee explained that when the sufferer wants to communicate a need or wish and he is not able to do it, this results in agitation, which generates nervousness. If the patient

gets nervous, then the blood pressure augments, which also originates a higher heart rate and derives in a suboptimal medical condition.

Another scenario described by a nurse tried to depict how improper communication can lead to unnecessary application of medication. She described a hypothetical situation where a patient has pain in the toes because she has had pillow underneath of them for a long time. If nurses are not able to understand properly the patient's messages, then, to alleviate the pain, they supply painkillers in a situation that can be avoided with simply by taking out the pillow.

Another hospital employee explained that she once observed that a patient was suffering with hallucinations. As the patient was not able to express what she was experiencing, she was continuously trying to unplug cables and take off the tubes. Then, the hospital employee manifested that if the patient could have communicated what she was experiencing maybe the nurses could have tried to calm her down without using sedation medication.

5.7 Suggestions and Observations from Participants

As the end point of the interview, patients were inquired about particular observations they may want to remark from their experience related to the ICU. Additionally, they were offered, to manifest any suggestion that could be of value for developing a software application to help ICU patients.

Hospital employees expressed that a communicator, if viable, could improve substantially the efficiency in the communication with the patient. One of the respondents explained that if the sufferer could better communicate, they would save a lot of time that they spend asking questions until they discover which was the concern of the patient or what he was trying to articulate. This communicator could save the hassle for the patient, which is a very important aspect in ICU.

However, contrary to what was stated by the majority of the interviewees, one of the participants confidently said that the communicator was not a viable idea. When consulted about the motive of her declaration, she manifested that the complexity of

the patient's needs makes "impossible" to solve the communication issues with a single device.

A comment performed by a doctor, suggested that different profiles should be considered, and pointed out some aspects to distinguish these profiles. First, the cultural level of the potential user is not the same for a person from a village than for somebody from the city. The language can also be an obstacle, so ideally the system should support several languages or, otherwise, the system would be hardly helpful for a foreign patient. The last aspect has to do with the age, as elderly people might not be used to technological devices like adults or young people. Therefore, they would incur in an additional effort to use the device considering their situation.

According to one respondent, elderly people sometimes are very problematic to communicate. Occasionally, elder patients seem unwilling to communicate, as if they were saying "leave me alone!".

Another interviewee stated that the available methods are not sufficient as her mother (the patient) is illiterate. Therefore, an illiterate person could not use a system entirely text-based.

A patient suggested that a communicator should have a method to call the nurse when it was necessary.

A nursing assistant explained about several problems that exist that should be taken into account when designing a device to aid patients' communication. To start, some patients have vision problems that could hinder their interaction with the system. As an example of this situation, she explained that some patients can benefit from text-based buttons, icon-based buttons, or the mix of them, in addition to their size. Also, patients with severe visual deficiencies cannot be considered part of the target group and therefore, a different non-visual approach should be used. Next, motor disorders are challenging to tackle as patients sometimes are not even able to move their hands. In addition, language can be problematic because some patients are admitted without a scheduled procedure. She told that once, a foreign patient was admitted in the ICU and the hospital staff could not determine his language, as he was unable to speak. None of the parts involved

was able to communicate properly. Lastly, sufferers with cognitive disorders that are tied to their beds with medication are not even able to hold a pen.

Chapter 6

Prototype Design

6.1 User-Centered Design

User-Centered Design (UCD) is the process of designing a product or service from the perspective of how it will be understood and used by users. The purpose of the process is to obtain a product or service that offers a more efficient, satisfying, and user-friendly experience for the use [30].

The UCD process, however, does not specify the exact methods needed for each phase that compose it, only provides an outline to follow.

The main principles in which is UCD is based are:

- The design is based on an explicit understanding of users, tasks, and environments
- The design is driven and refined by user-centered evaluation
- Users are involved throughout the design and development process
- The process is iterative
- The design team includes multidisciplinary skills and perspectives [31], [32]

The general phases that the UCD process encompasses are the following:

- Specify the context of use

- Specify requirements
- Create design solutions
- Evaluate the designs [31]

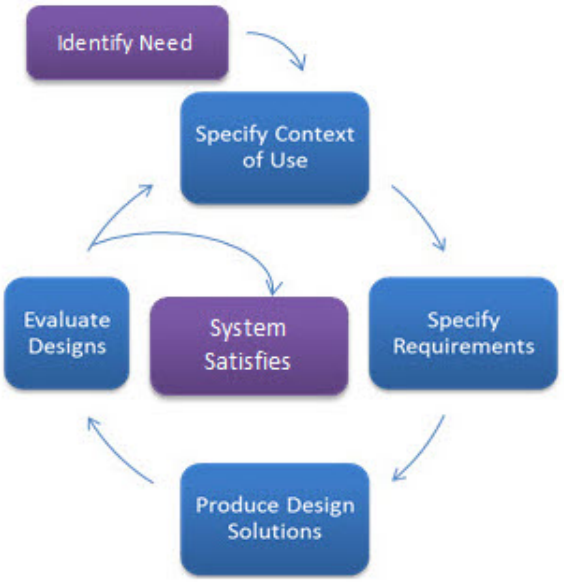

FIGURE 6.1: User-Centered Design Process.

6.2 Prototyping

A prototype can be anything from paper-based drawings to a complex piece of software, or from a cardboard mockup to a pressed piece of metal. It allows stakeholders to interact with an envisioned product to gain understanding and experience its possible uses.

Prototypes are a useful aid to discuss and to test ideas with stakeholders. They answer questions and support designers to choose between different alternatives [29]. Hence, they serve a variety of purposes:

- Test the feasibility of an idea
- Clarify ambiguous or vague requirements
- Perform user testing and evaluation
- Assert that the design direction is compatible with the rest of the system

6.2.1 Low-fidelity Prototypes

A low fidelity prototype is a prototype that doesn't look like the final product as the materials used are very different from those to be used in the intended final version. For example, paper and cardboard are used rather than electronic and metal screens. Low-fidelity prototypes are simple, cheap and quick to create. The benefit over other types of prototypes is that they are easy and inexpensive modifiable with few human and material resources, so they support exploring different alternative designs and ideas. At early stages of the development this is particularly useful as prototypes are for exploring ideas. In addition, the subjects participating in the design process, may feel more comfortable criticizing low fidelity prototypes than if the product would be an advanced version [28]. **Table 6.1** summarizes the advantages and disadvantages:

Advantages	**Disadvantages**
Low development cost	Limited error checking
Evaluate multiple design concepts	Poor detailed specification to code to
Useful communication device	Facilitator-driven
Address screen layout issues	Limited utility after requirements established
Useful for identifying market requirements	Limited usefulness for usability tests
Proof-of-concept	Navigational and flow limitations

TABLE 6.1: Advantages & Disadvantages of Low-fidelity Prototypes [29]

6.3 Design & Content

A low-fidelity prototype has been developed, which mainly consists of big buttons with messages. Each message represents a different wish, need or emotion that a patient could like to express.

The content of all the messages that are included in this application was elaborated based on the interviews' results and the literature review. Specifically the pre-recorded messages from the The Children's Hospital Boston Model in the **Section 3.2.1** of this document was used as a core set. Nevertheless, as those messages were aimed to children, a brainstorming session with the coordinator from the intensive care unit of the Hospital

Universitario de la Princesa was carried out to filter those that better suit our intended population.

After several iterations of refinement, the selected messages with minor modifications were categorized as follows:

- Needs
- Expressions of Discomfort or Pain
- Questions

The following messages were included into each category:

Needs:

- "I am cold"
- "I am hot"
- "I am thirsty"
- "Personal Hygiene"
- "The light bothers me"
- "I want my glasses"
- "I want something for the pain"
- "I want to get up/lay down"

Questions:

- "When is the visit hour?"
- "How am I doing?"
- "Why am I here?"
- "Can you put something on my feet?"
- "What is your name?"
- "Can I drink something?"

- "What time is it?"

Expressions of Discomfort or Pain:

- "I'm in pain"
- "I cannot breath"
- "I'm uncomfortable"
- "I need painkillers"
- "I need to change the posture"
- "I want to be suctioned"

When the button represents a more general concept such as "I cannot breath", once pressed, the user navigates to a new window with more specific messages. The underlying idea of the navigation is that the deeper the level in the hierarchy, the more specific the message is. Therefore, as "I'm in pain", "I cannot breath", "I'm uncomfortable" and "Personal Hygiene" were still too general concepts, they were divided into more specific messages:

I'm in pain:

- "Unbearable"
- "Bearable"
- "Constant"
- "Throbbing"
- "Crushing"

I cannot breath:

- "I'm choking"
- "I have chest pain"

I'm uncomfortable:

- "I have cramps"
- "I want to throw up"
- "I'm in pain"
- "Itches"
- "I want to defecate"
- "I want to urinate"
- "I feel burning"

The smiley face screen is a specific screen in the prototype that is entirely composed of pictograms. Next are listed the messages represented in the smiley face screen:

- "I am sad"
- "I am happy"
- "I am worried"
- "I am tired"
- "I am angry"
- "I want a drink"
- "Turn the lights off"
- "There is a lot of noise"
- "It's noisy"
- "I want to urinate/defecate"
- "I want painkillers"
- "I want to see a nurse"
- "I want to see a doctor"

In addition, each screen is divided into three colors: green, yellow and red. Each color represents a distinct urgency in the message that the user might want to manifest. For example, red denotes highly important or urgent messages; yellow indicates somehow urgent or important messages; and green is used for least urgent messages. Additionally,

within each colored column, messages are ordered according to their relevance and frequency of use. Although the order does not follow scientific evidence, the expertise of the hospital coordinator was used as an approximation.

Finally, as the expressiveness of the application is limited to the selected vocabulary, a virtual keyboard feature was included. This approach is similar to low technology tools like "Communication Boards" that use printed alphabet letters to build new messages selecting one letter after the other.

6.4 Prototype Illustration

The application starts at the initial screen where the buttons "Llamar" (Call) and "Conversar" (Talk) are displayed (**Figure 6.3**).

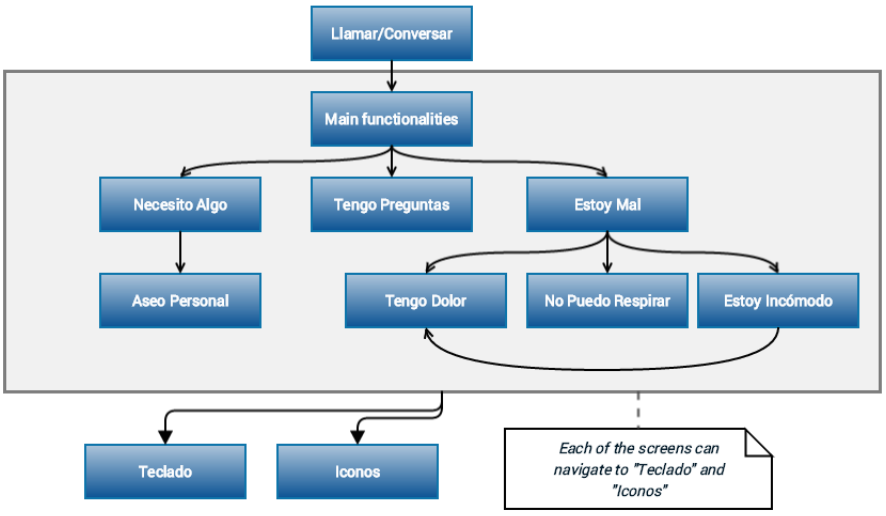

FIGURE 6.2: Prototype Navigation Map.

If the patient wants to call for help, then he has to press the "Llamar" (Call) button. In the case that the hospital member is already there, the patient simply has to press "Conversar" (Talk). This way, the application does not need to call for the hospital employee, as he is already there to communicate with the patient.

If the patient selected "Llamar" (Call), then, the application will display a message informing that somebody from the hospital staff will come to help him (**Figure 6.4**). Once the hospital member arrives, he unlocks the application using "Desbloquear" (Unlock) option. From this point the communication between the patient and the hospital member starts. Once the application is unlocked, it will display a screen with 6 buttons and a bottom menu. This screen exposes the main functionalities that the prototype provides.

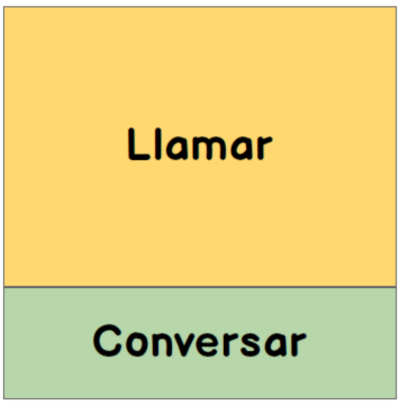

FIGURE 6.3: Prototype at the Initial Screen.

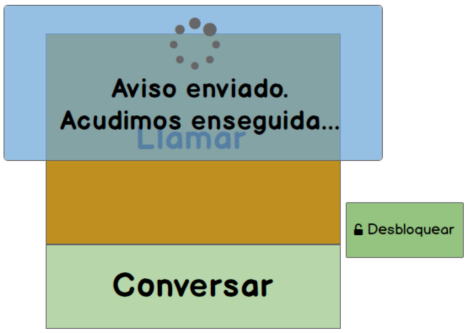

FIGURE 6.4: Prototype with the Screen Locked.

On the one hand, the bottom menu is present in all the screens of the application (except the initial screen) in order to provide quick access to a set of functionalities that can be used by the patient at any moment, regardless the context. The buttons that appear in the bottom menu are a smiley face button, a button labeled as "Teclado"(Keyboard) and a home button. The first button allows the user to go a screen where emoticons and other messages as are displayed (**Figure 6.5**). Examples of these messages are: "I'm in pain", "I need a doctor" and "I need painkillers". The second button, "Teclado" (Keyboard), displays a virtual keyboard where the user can type any message that he wishes to express. Lastly, the home button allows returning to the initial screen.

On the other hand, the other 6 buttons represent the main functionalities that the

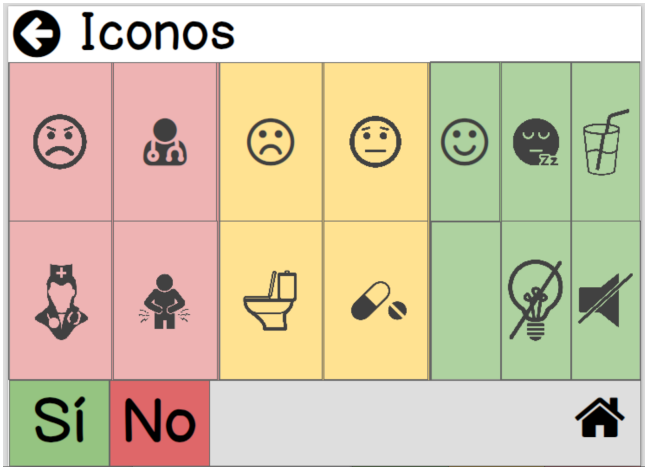

FIGURE 6.5: Prototype Iconos Screen.

application provides. In this screen, the user can select quick replies such as "Sí" (Yes), "No" (No) and "Estoy Bien" (I'm fine) or alternatively, he can choose more advanced functionalities like "Necesito Algo" (I need something), "Tengo Preguntas" (I have questions) or "Estoy Mal" (I'm bad). These last three allows the user to navigate in the hierarchy to more specific options.

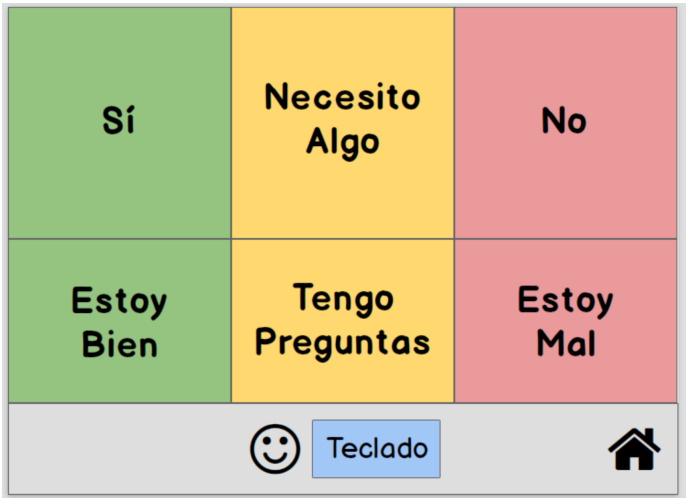

FIGURE 6.6: Prototype Main Screen.

For instance, if the user wants to communicate that he is suffering an unbearable pain in his right arm, then, he will presses "Estoy Mal" (I'm bad) → "Tengo Dolor" (I'm in pain). Once in the specific screen for pain, the patient could select "Insoportable" (Unbearable) and the right arm from the human body picture, as seen in the **Figure 6.7**.

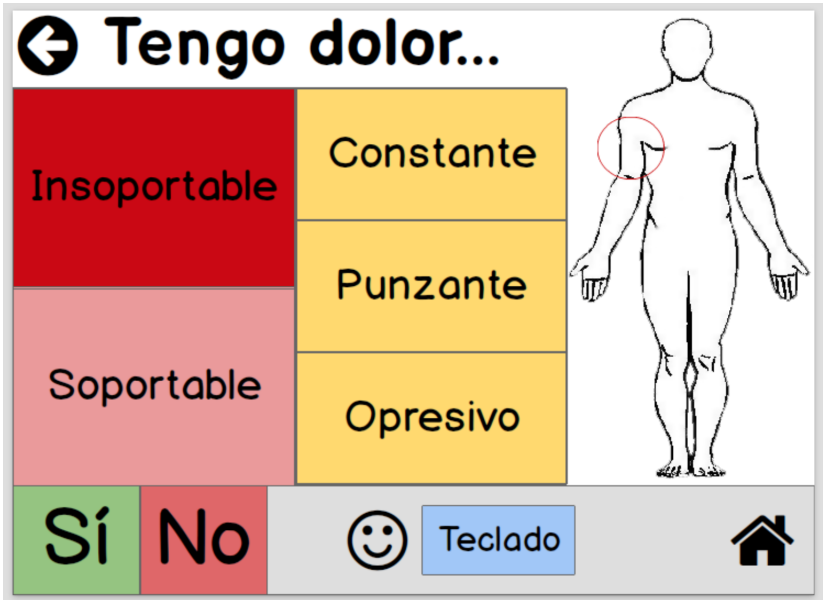

FIGURE 6.7: Prototype "Tengo Dolor" Screen with "Insoportable" and the right arm selected.

However, if the patient would like to know the name of a nurse that is taking care of him, the path is a bit different. The user should press "Tengo Preguntas" (I have questions) to go to the questions screen. Once there, he would select "¿Cuál es tu nombre?" (What is your name?) from the available options (**Figure 6.8**).

Another message that can be expressed using the prototype could be: "I'm thirsty". To be able to manifest this message, the user should press "Necesito Algo" (I need something) from the main screen, then, select "Tengo sed" (I'm thirsty) option (**Figure 6.9**).

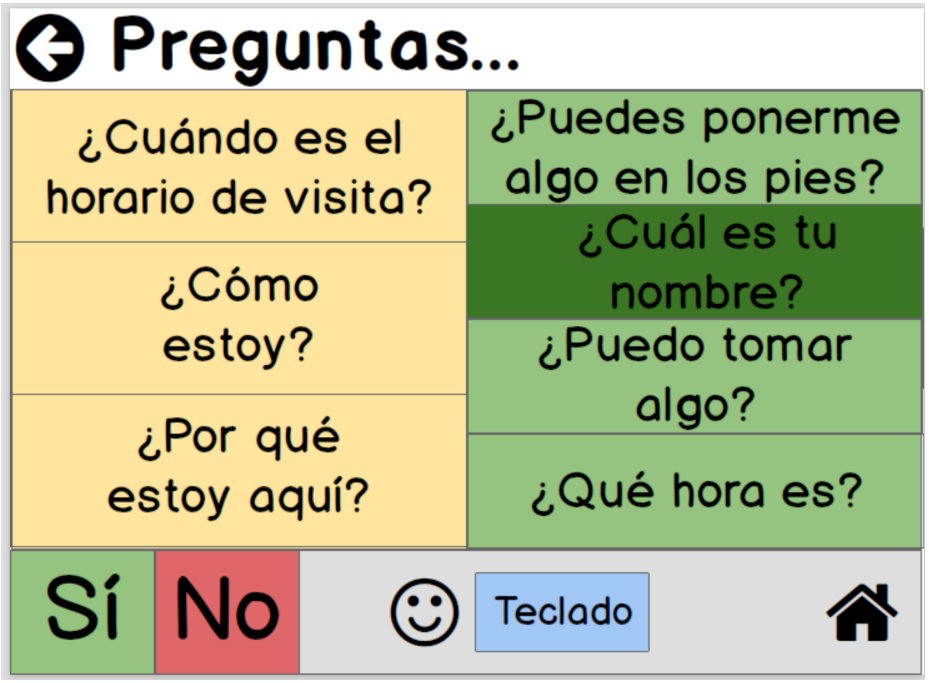

FIGURE 6.8: Prototype "Preguntas" Screen with the option "Cuál es tu nombre" selected.

FIGURE 6.9: Prototype "Necesito Algo" Screen with the option "Tengo sed" selected.

Chapter 7

Usability Evaluation: Design & Execution

7.1 Design of the Usability Evaluation

7.1.1 Introduction

This application prototype for tablets is directed to ICU patients with speech language impairments, with the objective of improving the communication with all the people involved in their environment. The prototype is based on a simple user interface with buttons associated to messages that the patient could use in a simple and quick manner.

This usability test consists of 9 tasks that the participant has to try to complete using the application prototype.

The aim of this test is to evaluate the prototype design using the think aloud protocol and measuring the effectiveness of the prototype. The results obtained from the test can help to detect problems and to improve the usability of the application.

During the test, notes will be taken about the participant comments and his body language on each task, as well as the overall development. In addition, measurements about the prototype effectiveness will be annotated.

Lastly, once all the tasks are finished, the participant will have to complete two questionnaires, one of satisfaction and the other about his impressions using the prototype. These questionnaires are attached in the **Appendix D** of this document.

7.1.1.1 Dates, Places and Roles in the Evaluation

The test sessions will be held on June 30, June 31, July 1, July 2 and July 3. Each season will be performed at the place of work of the participant or in a laboratory of the Universidad Politénica de Madrid.

A single researcher will conduct the test sessions. As a facilitator, his main job will be to interact with the participant presenting a short introduction of the activity that is going to be developed. Then, as observer, during the execution of each task, he will be in charge of taking notes about the actions and errors, as well as watch the general development of the activity.

7.1.1.2 Devices Available for the Evaluation

The participants will test the application prototype in a Nexus 9 tablet connected by Bluetooth to an Apple Trackpad. If the Apple Trackpad is not available or functional for any reason, a Microsoft Wedge Touch Mouse will be used in its place.

7.1.1.3 Participants

It is planned to recruit approximately 4 to 6 people to perform the usability test. These people must meet the patient selection criteria defined in the **Section 4.3** to be able to participate in the usability evaluation.

7.1.2 Procedure

Before starting the test, the participant must read and sign an informed consent. This document contains a general description of test, what the participant has to perform, what will be evaluated (the prototype not the participant), privacy and confidentiality

aspects, the reward perceived and the freedom to leave the test at any moment. The informed consent is attached in the **Appendix C** of this document.

To start, the participant is requested to complete a personal data questionnaire in order to statistically complement the results obtained from the test. Next, he will have to perform 9 tasks using the prototype that the researcher will explain one after the other. The questionnaires are attached in the **Appendix D** of this document.

While performing each task, the participant should try to express aloud what he thinks and plans to perform in order to better comprehend what the prototype's screens suggest to him and how he interprets them. Additionally, the researcher will take down notes of how the participant performs the tasks and when, where and why occur the difficulties expressed by him.

After all the tasks have been completed, the participant will be requested to complete two questionnaires to know his opinion about the system. The underlying idea is that the participant expresses all the problems he may have found in the prototype and all the aspects he may have not understood.

7.1.3 Task Instructions

- **Task 1 – Change the Posture:** Imagine that you have been in the same posture for several hours and you start to feel discomfort in the back. Using the prototype in the tablet, request to a nurse to change your posture.
- **Task 2 – Suffer Cold:** Suppose that it has been a hot day and, therefore, the air conditioner in the intensive care unit has been turned on at a low temperature during the whole day. Close to midnight, you feel your body is cold. Communicate with a nurse to ask to be covered to warm you up.
- **Task 3 – Pain in an Arm:** Imagine that after been several days in the intensive care unit, you feel an unbearable pain in the right arm. Using the prototype contact a nurse to tell her about the issue.
- **Task 4 – Breathing Problems:** Now imagine that after a tough night in the intensive care unit, you are finally about take a nap but you are suddenly wake

up because you have difficulties to breathe normally. Communicate with a nurse to express your breathing issues.

- **Task 5 – Feeling Sick:** Suppose that you have been with headache for several hours and suddenly, you start to feel like throwing up. Using the prototype in the tablet alert a nurse about your nausea.
- **Task 6 – Need to Urinate:** Now, imagine that you are sleeping and you wake up because you want to urinate. Call a nurse using the prototype to express your intention and to request a bedpan to urinate.
- **Task 7 – New Nurse:** Suppose that a new nurse has started to work in the intensive care unit today and you do not know her. Also, suppose that you have always liked to know the name of the persons that assist you in the intensive care unit. Use the prototype to know what is her name.
- **Task 8 – Watering Plants:** Suppose that in the visiting hours of the afternoon your husband/wife has come to see you. During the visit, you remember that your plants have been a long time without watering. Using the prototype tell her/him: **"do not forget to water the plants"**.
- **Task 9 – Answer to a Doctor:** Imagine that the doctor that usually visits you in the morning asks you if the pain you had in the back yesterday has decreased. Using the prototype to reply him that your back still hurts.

7.1.4 Metrics to be Collected

During the usability test, the next metrics will be collected for every task and participant:

- Number of elemental actions used to perform the task
- Number of errors made while performing the task
- Rate of task completion (by participant)

7.2 Evaluation Execution

Recruiting participants for the usability evaluation was a problematic. Firstly, one of the selected profiles (ICU patients) is not easy to find as it is a very specific and not so common profile. In fact, from patients in the intensive care unit of the Hospital Universitario de la Princesa, only a few met the selection criteria (**Section 4.3**) to take the test. Secondly, due to the tight schedule and time restraints, arranging the meetings with the participants that were able to perform the evaluation was difficult.

Furthermore, other complications arose when the researcher was about to conduct the tests. In particular, one of the ICU patients who had agreed to participate in the usability test unfortunately suffered a worsening of his health status, and then we decided it was not appropriate to make him participate in the evaluation. Regarding a second ICU patient who also agreed to participate in the evaluation, it was not possible to schedule a date to perform the usability test as she was still recovering from a medical procedure.

Finally, 5 participants with different profiles were able to participate in the usability evaluation:

- Two participants were former patients that were admitted in the ICU in the past
- Two participants have worked in the ICU in the past
- One participant was a family relative of an ICU patient

Regarding the test places, all the usability evaluations followed the planned procedure and were performed in the participants' work places or in their homes.

From the participants 3 were males and 2 were females, all of them with good experience using smartphones and their ages ranged from 30 to 66.

Chapter 8

Usability Evaluation: Results

8.1 Collected data

Following are presented all the collected data and the observation gathered of all the participants, grouped by task. All the results have been anonymized in order to maintain the confidentiality and privacy of the participants.

8.1.1 Task 1 - Change the Posture

Results			
Participant Id	**Finished Task Successfully**	**Actions**	**Errors**
P1	Yes	3	0
P2	No	3	0
P3	No	3	0
P4	Yes	6	0
P5	Yes	3	0

Table 8.1: Task 1 - Results

Observations:

- One of the participants explained that the button “Llamar” located at the initial screen is unnecessary, as while he was residing in the ICU he had an emergency button to call for attention

- Two participant that did not finish the task as it was planned. They chose a different option that might be interpreted as the result of the task ("Quiero acostarme/levantarme")
- One of the participants went first to "Necesito algo". As the message was not there, she continue navigating the prototype until she found the appropriate message
- One of the participants explained that he found the message in the first try, although he thinks that the message could also be under "Necesito Algo"

8.1.2 Task 2 – Suffer Cold

Results			
Participant Id	**Finished Task Successfully**	**Actions**	**Errors**
P1	Yes	3	0
P2	Yes	3	0
P3	Yes	3	0
P4	Yes	3	0
P5	No	3	0

Table 8.2: Task 2 - Results

Observations:

- One of the participants commented that the message was not found where he expected

8.1.3 Task 3 – Pain in an Arm

Results			
Participant Id	**Finished Task Successfully**	**Actions**	**Errors**
P1	Yes	4	0
P2	Yes	4	1
P3	Yes	5	0
P4	Yes	5	1
P5	Yes	4	0

TABLE 8.3: Task 3 - Results

Observations:

- Three participants did not select the arm in the human body drawing, as they considered that the task has been completed successfully
- One of the participants expected to see more options detailing body parts to choose
- A participant selected the lower part of the arm expecting to choose the entire arm

8.1.4 Task 4 – Breathing Problems

Results			
Participant Id	**Finished Task Successfully**	**Actions**	**Errors**
P1	Yes	4	0
P2	Yes	4	0
P3	Yes	3	0
P4	Yes	4	0
P5	Yes	5	1

Table 8.4: Task 4 - Results

Observations:

- At this point in the usability test, one of the participants commented that so far the tasks were repetitive in the interaction with the prototype
- One of the participants stated that for her the task was over when the options "Me ahogo" or "Tengo dolor en el pecho" were displayed. Therefore, she did not want to select more choices
- Another participant commented that the task needed more details to be understood

8.1.5 Task 5 – Feeling Sick

Results			
Participant Id	**Finished Task Successfully**	**Actions**	**Errors**
P1	No	10	1
P2	Yes	4	0
P3	Yes	4	0
P4	Yes	7	0
P5	No	3	0

Table 8.5: Task 5 - Results

Observations:

- Although the participant P1 navigated all the prototype screens trying to find the message, he did not finish the task. He did not associate nausea with "I want to vomit". Also, he pushed accidentally the home button to go back to the previous screen, where he gave up

- A participant went first to "Necesito algo". Then, she went to the initial screen and continue navegating until the message for the task appeared
- A participant commented that the option was not found where he expected

8.1.6 Task 6 – Need to Urinate

Results			
Participant Id	**Finished Task Successfully**	**Actions**	**Errors**
P1	Yes	9	1
P2	Yes	4	0
P3	Yes	4	1
P4	Yes	11	0
P5	No	3	0

TABLE 8.6: Task 6 - Results

Observations:

- The participants P1 and P4 found the desired messages after going forward and backwards several times
- Once participant P1 found the message, he commented that for him "I want to urinate" cannot be considered as "Personal Hygiene"
- A participant commented that the option was not found where he expected

8.1.7 Task 7 – New Nurse

Results			
Participant Id	**Finished Task Successfully**	**Actions**	**Errors**
P1	Yes	3	0
P2	Yes	3	0
P3	Yes	5	0
P4	Yes	3	0
P5	Yes	3	0

Table 8.7: Task 7 - Results

Observations:

- One of the participants went directly to the keyboard functionality to write it. Afterwards, she navigated until the message intended for the task was found.

8.1.8 Task 8 – Watering Plants

Results			
Participant Id	**Finished Task Successfully**	**Actions**	**Errors**
P1	Yes	6	0
P2	No	7	0
P3	Yes	5	0
P4	Yes	4	0
P5	No	4	1

Table 8.8: Task 8 - Results

Observations:

- On of the participants stayed a couple of seconds thinking in silence in the main screen. Then, instead of using the quick button "Teclado" in the bottom menu for quick access, he used a different path to reach the virtual keyboard functionality. The path used was "Llamar"→ "Necesito Algo"→ "Teclado"
- Another participant also used "Llamar"→ "Necesito Algo"→ "Teclado" instead of using the same button
- One of the participants navigated all the menus in the prototype with the exception of the smiley icon in the bottom menu bar. He explained that he saw the "Teclado" button but did not realize it was labeled as "Teclado"

- The participant P5 went to "Necesito Algo" and the stopped as he did not find the option

8.1.9 Task 9 – Answer to a Doctor

Results			
Participant Id	**Finished Task Successfully**	**Actions**	**Errors**
P1	Yes	3	0
P2	No	6	0
P3	Yes	2	0
P4	Yes	2	0
P5	Yes	2	1

Table 8.9: Task 9 - Results

Observations:

- The participant P1 used a longer path but achieved the task objective. The path used was "Llamar"→ "Necesito Algo"→ "No".
  The shortest path for this task was: "Llamar"→ "No"
- A participant did not finish the task, as he was trying to answer literally "I still have pain"
- Two participants did not understand that the doctor was standing in front of her/him. So, he/she used "Llamar" option rather than "Conversar". However, they finished the task successfully

8.1.10 Participants Rate of Task Completion

Results	
Participant Id	**Rate of Task Completion**
P1	8/9 (88%)
P2	6/9 (66%)
P3	8/9 (88%)
P4	9/9 (100%)
P5	5/9 (56%)

Table 8.10: Rate of Task Completion - Results

8.2 Analysis of the Usability Evaluation

8.2.1 Suggestions and Impressions

After performing the usability evaluation, the participants completed two questionnaires, one of impressions and the other of satisfaction (SUS Satisfaction Questionnaire). The first had the objective of collecting which are the positive and negative aspects of the prototype according to the participants. The satisfaction questionnaire aimed at evaluating the usability of the prototype.

The most relevant and interesting responses were the following:

- "The 'Yes' and 'No' buttons at the initial screen, seem out of context, considering the other options"
- "I have liked everything in general"
- "The prototype was easy and intuitive to use"
- "The pictograms used in the bottom menu are not clear"
- "The keyboard button could be relocated in other place"
- "The design is attractive"
- "The prototype was comfortable to use"
- "The characteristic I have liked the most is the idea"
- "My overall experience with the prototype was good and it was easy to use"
- "I liked that the prototype is quite simple and basic in the content"
- "I liked the simplicity of the prototype"

The participants also suggested some improvements in the prototype:

- Messages should be as formal as possible
- Speech Synthesis could be added
- "Aseo Personal" is not an appropriate name for the content that it hosts. For example, "Quiero orinar" or "Quiero defecar"

- "More options to select the location of the pain"
- "The initial screen buttons ("Llamar" and "Conversar") should be the biggest possible. All the empty white space that appears in the screen is wasted"

8.2.2 Tasks Analysis

8.2.2.1 Task 1

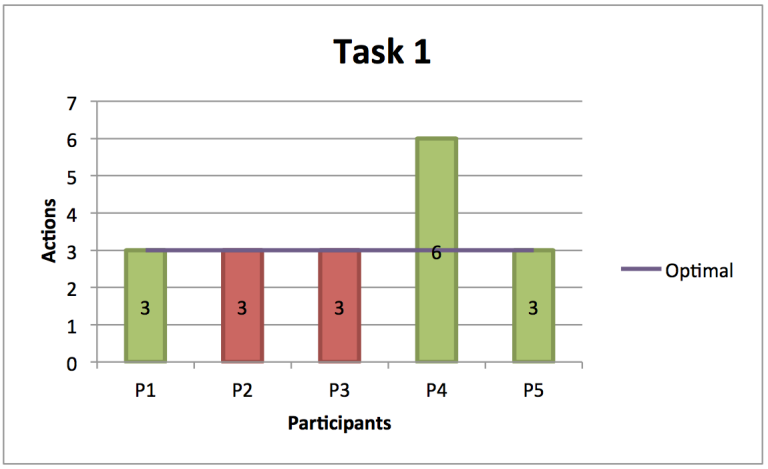

FIGURE 8.1: Task 1 - Actions per Participant.

- It can be seen from the **Figure 8.1** that two participants did not finish the task but performed a few actions. This may be because they thought they had completed the task successfully using another option. Also, we can see that a the participant have performed a number of actions over the optimal. Probably, this participant was not able to find the option, so he continued searching until the option appeared

8.2.2.2 Task 2

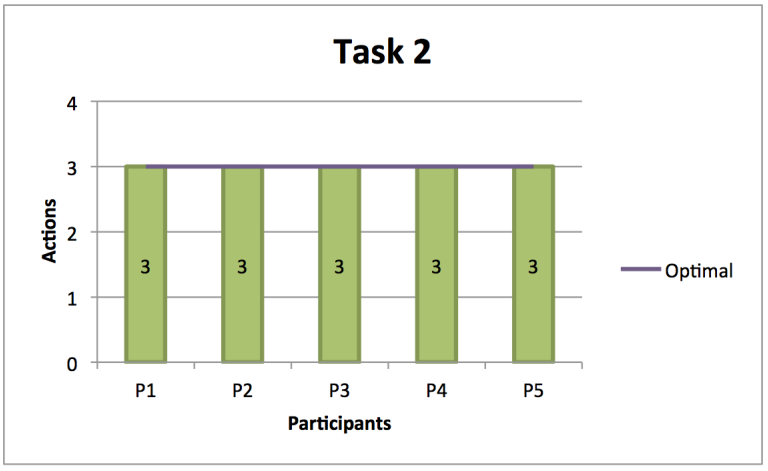

FIGURE 8.2: Task 2 - Actions per Participant.

- From the **Figure 8.2** we can see that all participants finished the task successfully without errors

8.2.2.3 Task 3

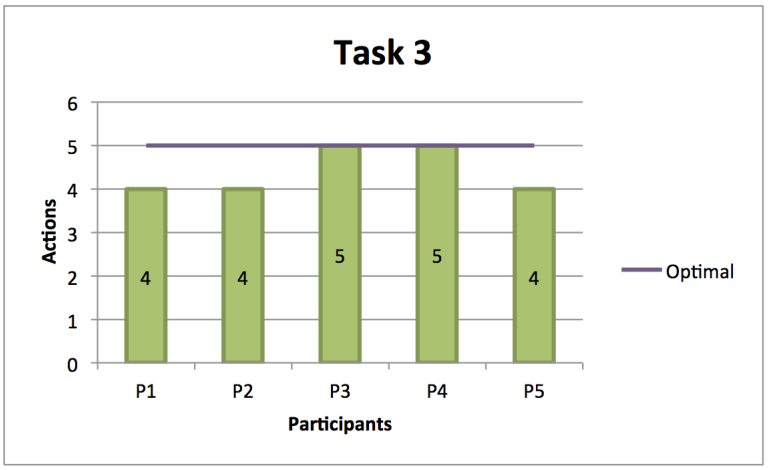

FIGURE 8.3: Task 3 - Actions per Participant.

- As shown in the **Figure 8.3** all participants finished the task successfully. However, the number of actions used of some participants differs from the optimal. The reason might be that the drawing did not have visual aids to determine that it was selectable. This fact was evidenced with the participants comments during the task.

8.2.2.4 Task 4

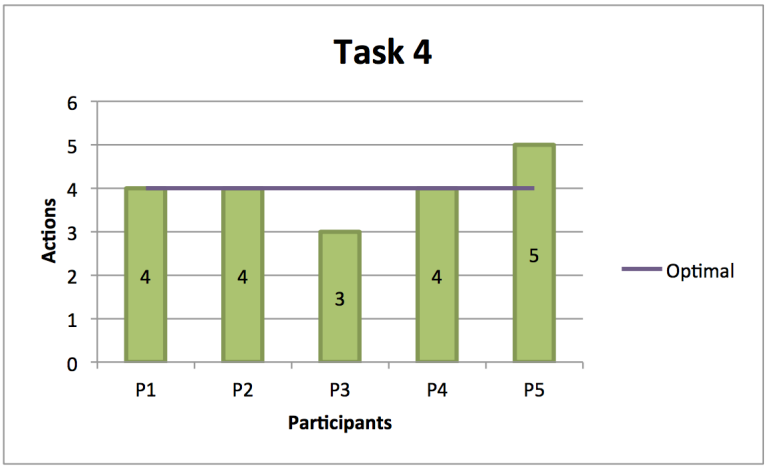

FIGURE 8.4: Task 4 - Actions per Participant.

- From the **Figure 8.4** we can see that all the participants finished the task successfully. Nevertheless, we can see that some participants used less number of actions than the optimal. This might be as some participants considered that the task was finished and they had expressed the task objective. In addition, a participant used an extra action to complete the task. This might be due to he changed the selected option for another option, as he thought that the other option was better to express the task objective.

8.2.2.5 Task 5

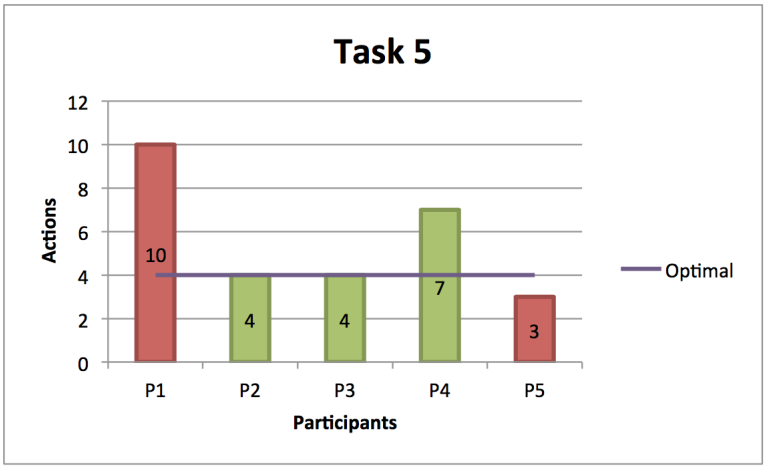

FIGURE 8.5: Task 5 - Actions per Participant.

- As seen in the **Figure 8.5** we can see that not all the participants were able to complete the task. One of the participants tried to search the option and finally we gave up. Probably, he stopped trying when he committed an accidental error (as detailed in the observations of **Table 8.5**).

  Another participant spent more actions from the optimal but finally, he was able to achieve the task objective. This might be as he continue searching for the option in another menu.

  Lastly, a participant spent a few actions quickly give up as the option did not was where he expected (as noted in the observations of **Table 8.5**)

8.2.2.6 Task 6

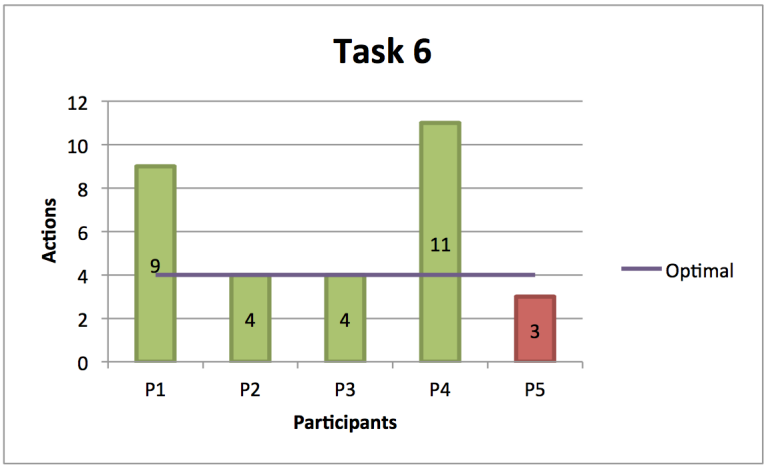

FIGURE 8.6: Task 6 - Actions per Participant.

- As shown in the **Figure 8.6** most of the participants were able to finish the task. Nevertheless, we can see that some of them needed more actions, compared to the optimal, to perform the task objective. Probably, the main reason might be that the option was not located were they expected. Also, we can see that the participants that have a high number of actions are also the ones who committed more errors.

8.2.2.7 Task 7

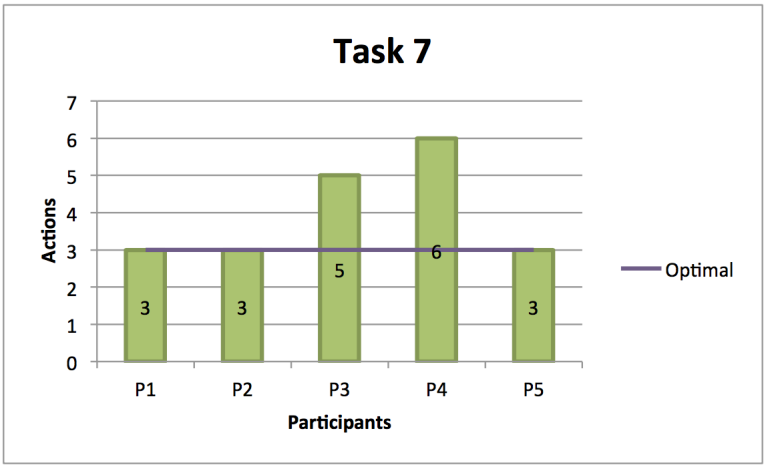

FIGURE 8.7: Task 7 - Actions per Participant.

- From the **Figure 8.7** we can see that all the participants finished the task successfully. However, there were two specific participants that used more actions from the optimal to complete the task. From the observations from the **Table 8.7**, we can see that these participant tried a different path to achieve the task objective.

8.2.2.8 Task 8

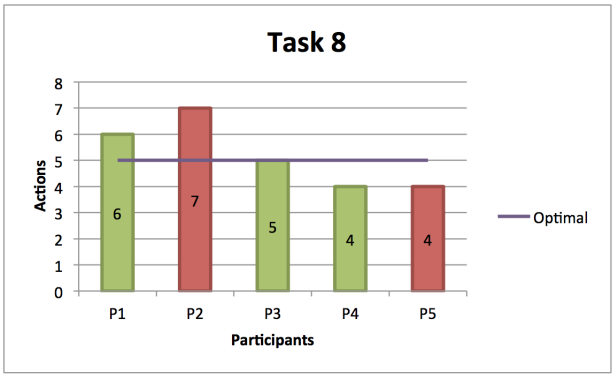

FIGURE 8.8: Task 8 - Actions per Participant.

- The **Figure 8.8** shows in this task not all participants were able to complete it. Regarding the ones that finished successfully, only one spent more actions than the

optimal. This might be as the participant used a different path to reach the option (as noted in the observations from **Table 8.8**). The other participants, the ones who did not completed the task, they did not find the option where they expected.

8.2.2.9 Task 9

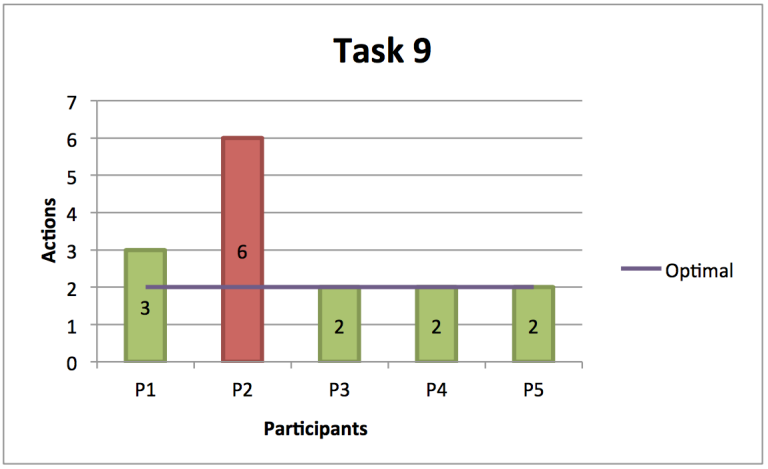

FIGURE 8.9: Task 9 - Actions per Participant.

- Most of the participants were able to finish the task successfully. Regarding the participant that did not finish the task, he tried completing the task in a different way than it was planned

8.2.2.10 Participants Rate of Task Completion

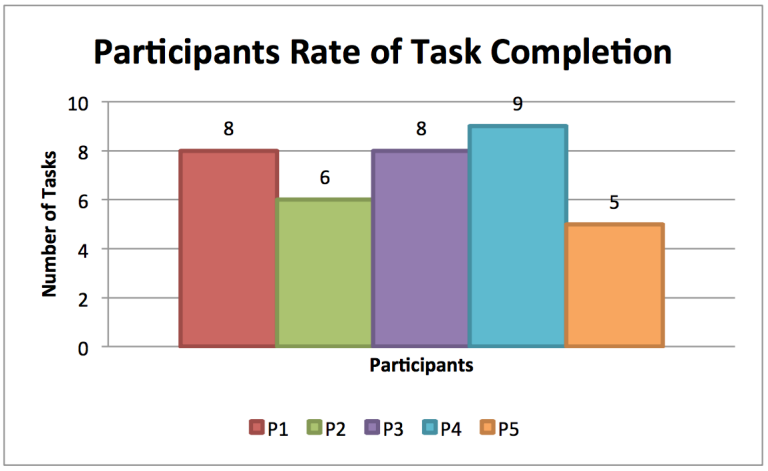

FIGURE 8.10: Participants Rate of Task Completion.

- As shown in the **Figure 8.6**, we can see that all the participants finished most of the tasks. In addition, there was no participants who have performed all the task successfully.

8.2.3 Problems Identified

Following are listed the problems that have been identified after analyzing the collected data, the observation notes and the suggestions and feedback from the participants:

Problem 1 The sensitivity of the Apple Trackpad was a problem for some participants. For some of them, it was the first time using a device of these characteristics. Hence, in some occasions accidental double taps were performed using the device.

Problem 2 Although it was briefly explained before starting the test, some participants did not understand the difference between "Llamar" and "Conversar" buttons.

Problem 3 Some participants had troubles to identify which option was suitable to perform the task. Particularly, the confusion was between "Necesito Algo" and "Estoy Mal'. This was evidenced in **Tasks 1**, **5** and **6**, as shown in **Figure 8.1**, **8.5** and **8.6**, where the number of actions was much higher than the optimal actions.

Problem 4 The visual aspect of the prototype caused problems to some participants. Specifically, direct light on the device and the size of the text were issues for adults with glasses.

Problem 5 Some messages were pointed as wrongly located under certain menus such as "Necesito cambiar de postura" in "Estoy mal" and "Me molesta la luz" in "Aseo personal" (**Task 1**).

Problem 6 Most of the participants did not try to select the body part that was hurting in the human body drawing, as they did not think it was for that purpose (**Task 3**).

Problem 7 Some participants pointed that some messages were repeated in different sections. For instance, "Quiero orinar" and "Quiero defecar" were included within "Aseo personal" and "Estoy Incómodo".

Problem 8 The "Llamar" and "Conversar" buttons do not use the entire space available on the screen.

From the list of problems identified, the following scale was used to rate the severity of the usability problems found [33]:

- **Value 0 - It is not a problem:** the author does not think it is a usability problem
- **Value 1 - Cosmetic problem only:** need not be fixed unless extra time is available
- **Value 2 - Minor usability problem:** fixing this should be given low priority
- **Value 3 - Major usability problem:** important to fix, so should be given high priority
- **Value 4 - Usability catastrophe:** imperative to fix this before product can be released

8.2.3.1 Severity of the Usability Problems Found

Problem	Severity Value	Observation
Problem 1	3 or 4	As the main interaction mechanism with the prototype is through the Apple Trackpad, it is of vital importance to count with a flexible device to suit patient's motor skills, which in fact are quite diverse.
Problem 2	2 or 3	The concept of these two buttons was not clearly understood by participants.
Problem 3	2	-
Problem 4	3	-
Problem 5	3	Some messages were expected to be within other menus. For instance, "Quiero defecar", "Quiero orinar" and "Me molesta la luz".
Problem 6	2	The human body drawing did not have any visual aid to suggest that it is was selectable.
Problem 7	2	-
Problem 8	2	This layout issue could have impact in users with impairments in their motor skills.

Table 8.11: Severity of the Usability Problems Found.

8.2.4 Improvements

Next are presented some improvements that may solve the problems listed in **Section 8.2.3**. These improvements will be implemented and evaluated in the next design iteration.

Solution 1: To solve this issue, depending on the participant, the sensitivity could be configured from the tablet. If there are still problems, other devices could be used such as single switches or pressure switches.

Solution 2: The buttons could be replaced by a unique button. If the hospital employee was at bedside, then the call could be canceled because of the proximity of him with the device. Furthermore, this would solve **Problems 5** and **7**.

Solution 3: Reorder the messages within the menus could solve this issue. However, this decision may affect the size of the elements of the prototype.

Solution 4: Screen protectors with anti-glare could be used to reduce the visibility issues or, alternatively, other devices could be employed to test if they have the same effect. Regarding the font size, as the biggest font available was already used in the prototype, a bigger screen device such as a TV screen could be used.

Solution 6: Each body part could have a colored outline to visually suggest that is selectable

Solution 8: Increase the buttons size to the device screen limits.

Chapter 9

Conclusions & Future Work

9.1 Conclusions

The literature review allowed us to understand the needs, the context and the problems that patients in intensive care unit have from the perspective of different researchers. These researches exposed the objectives, the procedures and the methods used. Their findings allowed us to obtain a general overview and at the same time, understand the current problematic of communication that patients suffer.

The qualitative study provided valuable information in first person about the difficulties that patients often experience when they reside in the intensive care unit. The interviews performed with patients, families and hospital staff reflected that patients often have great difficulty communicating their needs and emotions.

The tools available in the intensive care unit environment are often not enough to allow patients to express themselves. The different types of patients that reside are often very complex due to their medical condition and also as they have distinct needs. Consequently, there seems not be a universal method to solve all communication problems that patients have.

The planning of usability tests with the developed prototype showed that the selected profile (ICU patients) is not easy to find, as it is a very specific and not so common. In

addition, the patients' medical condition varies constantly making it difficult to count with them for testing.

Due to these difficulties found in recruiting test participants, only a low number of them could do the usability test, thus affecting to the overall results validity. Nevertheless, the results are promising, showing that the prototype might allow patients to communicate effectively.

The results of usability evaluation of the prototype proved that the participants were able to perform most of the tasks effectively.

Anyway, the results provide valuable information to improve the design of the prototype for further refinement iterations.

9.2 Future Work

Although we developed and tested the prototype. it is still not enough to ensure that it will meet all the patient's needs in the intensive care unit. More research is still needed to improve the presented design.

The result of this work, that is, the design of the prototype, only presents an initial approximation to the problems that patients have int their communication. In addition, it is necessary to plan and execute new usability evaluations with a higher user base, matching the appropriate profile.

Furthermore, different patients' profiles were not considered in this research that could be studied and analyzed to complete and complement the design of the prototype. In this way, it would be possible to cover the communication problems of a broader spectrum of patients.

Another possible line of work could be to develop a dedicated device to interact with the prototype instead of using an Apple Trackpad. This device is not suitable for all patients, especially those who have problems with their fine motor skills .

Finally, we believe that it would be useful the implementation of a voice synthesizer and pictograms for messages. These features could include another type of profile that was

not contemplated in the design of this prototype such as illiterate or vision impaired people.

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Appendix A

Questions for Interviews

Questions for Former Patients:

- How did you communicate with other people while you were in the intensive care unit?
- Which were the most important needs that you tried to communicate? Was it possible to do it? How?
- What worked best for you in terms of communication? (Tool related)
  - Which were the tools that you used while staying in the intensive care unit?
    - How was the first interaction with these tools you have? Was in preoperative meetings or once admitted to the intensive care unit?
    - Were these tools based on technology such as tablets or smartphones? Which ones?
- Have you had difficulties to communicate with your relatives while staying in the intensive care unit? And with the members of the hospital staff?
- Which feelings have you experienced while trying to communicate with other people in the intensive care unit? When and how did this usually happen?
- Were there situations when you could not express specifically your needs to your relatives? And to the members of the hospital staff? When and how did this usually happen?
- Were there situations when the members of the hospital staff erroneously interpreted your messages? Which messages? Was it the same for your relatives? Why?

• How did you express urgent messages while staying in the intensive care unit? Was it problematic? In what moments did this happen? Why? And how did that make you feel?

• How would it have helped if you had been able to express yourself better?

• Which were the most common needs that you manifested on a daily basis?

• In your opinion, what should the communicator do in order to help you communicate better?

• Is there a situation, need, concern or worry you would like to comment in order to help us?

Questions for Hospital staff:

• In what way did patients communicate while staying in the intensive care unit?

• Do they use tools to communicate? (Such as boards with letters, pen and paper, tablets, etc.)

  – Which are these tools that patients use when they are in intensive care unit? (Patients with tracheostomy or intubation)

• In which moment are they taught how to use these communication tools? In the intensive care unit or preoperative meetings? Can you describe these communication tools?

• How is decided which tool suits best each patient?

• Which are the communication problems that patients suffer in the intensive care unit? Have these problems affected the medical treatment or your work?

• Do the available communication tools satisfy the needs of the patients? Why or why not?

• Have patients felt fear when trying to communicate? And frustration?

• Have patients expressed messages that were not understood by the receivers? And erroneous interpretations?

• How do patients express urgent messages? Is it problematic for them to do it? In what situations did this happen?

• Which were the most common needs expressed by patients?

• Did the communication issue affect your work or the treatment? In what ways?

• Is there a situation, need, concern o worry you would like to comment in order to help us?

Questions for Patient Relatives:

• In what way did your relative communicate with you while staying in the intensive care unit?

• Did she or he use any tool to communicate with you? Did you know any of these tools before your relative was admitted to the ICU? If so, can you explain which they were, and can you describe how they worked?

• Which were the difficulties to communicate that you observed when your relative was admitted?

• Was your relative able to express her or his needs to communicate? How was it regarding the communication with you? And with the hospital staff? Did the use of these tools affect the communication?

• Was your relative able to express her or his needs in a clear manner? Were there erroneous interpretations? Was she or he able to manifest urgent messages? Why? Were they solved?

• Which were the needs that your relative tried to express mostly?

• What should a communicator have in order to improve the communication?

• Is there a situation, need, concern o worry you would like to comment in order to help us?

Appendix B

Personal Questionnaires

B.1 Cuestionario para Paciente

Hospital Universitario de la Princesa, Madrid, España
Universidad Politécnica de Madrid, España

Datos Personales

Fecha:

Edad:

Sexo: Varón ☐ Mujer ☐

Nivel de estudio:

Tiempo en UCI:

- ☐ 1 semana
- ☐ 1-2 semanas
- ☐ 2-4 semanas
- ☐ $>$ 1 mes

- Grupo de Ingreso:
  - ☐ Programado
  - ☐ Urgente

B.2 Cuestionario para Personal UCI

Hospital Universitario de la Princesa, Madrid, España

Universidad Politécnica de Madrid, España

Datos Personales:

Fecha:

Edad:

Sexo: Varón ☐ Mujer ☐

Categoría Profesional:

Tiempo de trabajo en UCI:

B.3 Cuestionario para Familiar

Hospital Universitario de la Princesa, Madrid, España

Universidad Politécnica de Madrid, España

Datos Personales

Fecha:

Edad:

Sexo: Varón ☐ Mujer ☐

Nivel de estudio:

Cuidador: Principal ☐ No Principal ☐

Grado de parentesco:

Grupo de Ingreso:

Tiempo en UCI:

- ☐ $<$ 1 semana
- ☐ 1-2 semanas
- ☐ 2-4 semanas
- ☐ $>$ 1 mes

Appendix C

Informed Consents

C.1 Informed Consent for Participant (Interviews)

Consentimiento Informado para Participante en Proyecto COMUNICA

Hospital Universitario de la Princesa, Madrid, España

Universidad Politécnica de Madrid, España

Título del Proyecto: Estudio de Usabilidad para el Diseño de un Comunicador para Pacientes UCI con Dificultades de Comunicación

Investigadores: Joaquín Tita, Gema Vega González, Xavier Ferré Grau, Cristian Moral Martos

C.1.1 Propósito de la Investigación/Proyecto

Usted está invitado a participar en un estudio cuyo propósito es comprender mejor cuáles son los problemas, experiencias, deseos y necesidades que experimentan tanto los pacientes que se encuentran ingresados en cuidados intensivos, como el personal médico y los familiares que se comunican con ellos. Dicha información será utilizada posteriormente para diseñar un sistema informático capaz de dar respuestas a dichas necesidades de la forma más intuitiva, sencilla y eficiente posible.

C.1.2 Procedimientos

A su llegada, se le dará una introducción sobre la investigación, objetivos y procedimientos de estudio. Luego de haber leído y firmado el consentimiento informado se procederá a realizar una entrevista. Esta entrevista, si usted lo autoriza, será grabada (sólo la voz) para que luego los investigadores puedan analizarla con mayor nivel de profundidad. A su vez, deberá completar un formulario con sus datos personales cuyo fin es complementar de forma estadística los datos que recabemos con la entrevista. Este formulario será proporcionado por los investigadores antes de comenzar la entrevista pero una vez firmado este consentimiento.

C.1.3 Riesgos

No se espera que haya riesgos de ningún tipo derivados de la realización de la entrevista.

C.1.4 Beneficios de este estudio

Por su participación, Ud. No obtendrá ningún beneficio. Su participación en esta investigación proporcionará información que pueda ser utilizada para elaborar de una manera más precisa y centrada en el usuario, una herramienta de comunicación en cuidados intensivos.

C.1.5 Recogida de Datos

Para facilitar la recogida de datos, si usted lo autoriza, la entrevista será grabada (sólo audio) para poder realizar un análisis posterior una vez concluida la entrevista.

C.1.6 Alcance de Anonimato y Confidencialidad

Los resultados de su participación serán confidenciales. Es decir, cualquier persona ajena a la investigación no tendrá acceso a las grabaciones, notas y/o cuestionario personal que se generen antes, durante y después de la entrevista. Su consentimiento escrito es necesario para que los investigadores puedan proporcionar si hubiere auditorias, cualquier información que lo identifique como participante a las personas involucradas en

la investigación. Su nombre será eliminado de toda información que provea (incluyendo notas, grabaciones y cuestionario personal) y sólo será identificado por un número de participante en el análisis y en cualquier posible informe o publicación que derive de este estudio.

C.1.7 Compensación

Su participación es voluntaria y no remunerada.

C.1.8 Libertad para abandonar la investigación

Usted es libre de abandonar este estudio en cualquier momento y por cualquier motivo sin necesidad de dar explicación alguna.

C.1.9 Responsabilidades y Permiso del Participante

Yo accedo voluntariamente a participar en estudio y no conozco ninguna razón por la cual no pueda participar. He leído y comprendo el consentimiento informado y condiciones sobre este estudio. Se me ha dado la oportunidad de hacer preguntas y todas ellas han sido contestadas satisfactoriamente. Yo, habiendo comprendido lo anteriormente expuesto, doy mi consentimiento voluntario para participar en este estudio. En el caso de participar, puedo retirarme en cualquier momento sin penalización ni justificación. Por último, estoy de acuerdo en cumplir las reglas de este proyecto.

Firma: _____ Fecha: _____

Nombre: _____

Teléfono o Dirección (OPCIONAL): _____

Correo Electrónico (OPCIONAL) _____

C.2 Informed Consent for Participant (Usability Evaluation)

Consentimiento Informado para Participante en
Proyecto COMUNICA

Hospital Universitario de la Princesa, Madrid, España
Universidad Politécnica de Madrid, España

Título del Proyecto: Estudio de Usabilidad para el Diseño de un Comunicador para Pacientes UCI con Dificultades de Comunicación

Investigadores: Joaquín Tita, Gema Vega González, Xavier Ferré Grau, Cristian Moral Martos

C.2.1 Propósito de la Investigación/Proyecto

Usted está invitado a participar en un estudio cuyo propósito es comprender mejor cuáles son los problemas, experiencias, deseos y necesidades que experimentan tanto los pacientes que se encuentran ingresados en cuidados intensivos, como el personal médico y los familiares que se comunican con ellos. Dicha información será utilizada posteriormente para diseñar un sistema informático capaz de dar respuestas a dichas necesidades de la forma más intuitiva, sencilla y eficiente posible.

C.2.2 Procedimientos

A su llegada, se le dará una introducción sobre la investigación, objetivos y procedimientos de estudio. Luego de haber leído y firmado el consentimiento informado deberá completar un formulario con sus datos personales. Dicho cuestionario tiene como fin complementar sus características con fines de obtener resultados estadísticos de los participantes que realicen la prueba de usabilidad. Una vez completado el cuestionario personal, se procederá a realizar la prueba de usabilidad sobre un prototipo del sistema informático. Esta prueba consiste en que usted realice 9 tareas utilizando el prototipo en una tablet. Estas tareas serán explicadas una a una por uno de los investigadores a medida que las vaya completando. Luego de completar todas las tareas con el prototipo, deberá rellenar un

cuestionario de impresiones sobre el prototipo. Este cuestionario tiene como objetivo recoger su opinión y sugerencias sobre el prototipo sobre el cual realizó las tareas. Para finalizar, deberá completar un cuestionario de satisfacción sobre su experiencia al realizar la prueba de usabilidad.

C.2.3 Riesgos

No se espera que haya riesgos de ningún tipo derivados de la realización de la prueba de usabilidad.

C.2.4 Beneficios de este estudio

Su participación voluntaria y no remunerada. Su colaboración en esta investigación proporcionará información que pueda ser utilizada para elaborar de una manera más precisa y centrada en el usuario, una herramienta de comunicación en cuidados intensivos. Dicha herramienta tendrá como beneficiarios a los futuros pacientes de cuidados intensivos cuya comunicación se ve altamente afectada.

C.2.5 Alcance de Anonimato y Confidencialidad

Los resultados de su participación serán confidenciales. Es decir, cualquier persona ajena a la investigación no tendrá acceso a las notas y/o cuestionarios que se generen antes, durante y después de la prueba de usabilidad. Su consentimiento escrito es necesario para que los investigadores puedan proporcionar, si hubiere auditorias, cualquier información que lo identifique como participante a las personas involucradas en la investigación. Su nombre será eliminado de toda información que provea (incluyendo notas y cuestionarios completados) y sólo será identificado por un número de participante en el análisis y en cualquier posible informe o publicación que derive de este estudio.

C.2.6 Libertad para abandonar la investigación

Usted es libre de abandonar este estudio en cualquier momento y por cualquier motivo sin necesidad de dar explicación alguna.

C.2.7 Responsabilidades y Permiso del Participante

Yo accedo voluntariamente a participar en esta prueba de usabilidad y no conozco ninguna razón por la cual no pueda participar. He leído y comprendo el consentimiento informado y condiciones sobre esta prueba de usabilidad. Se me ha dado la oportunidad de hacer preguntas y todas ellas han sido contestadas satisfactoriamente. Yo, habiendo comprendido lo anteriormente expuesto, doy mi consentimiento voluntario para participar en esta prueba de usabilidad. En el caso de participar, puedo retirarme en cualquier momento sin penalización ni justificación. Por último, estoy de acuerdo en cumplir las reglas de este proyecto.

Firma: _____ Fecha: _____

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Appendix D

Evaluation Plan

D.1 Planificación de Evaluación de Usabilidad

D.1.1 Producto Evaluado

El prototipo a evaluar corresponde al diseño de una aplicación para tablets que los pacientes con problemas en el habla que se encuentran en la Unidad de Cuidados Intensivos (UCI) podrían utilizar para comunicarse de forma rápida y sencilla. El prototipo se basa en una interfaz sencilla con botones con mensajes que el usuario podría utilizar de forma cotidiana para comunicarse con el personal médico de la UCI, como así también con sus familiares y amigos.

D.1.2 Objetivos de la Evaluación

- Evaluar el diseño desarrollado frente al modelo mental de los usuarios, mediante el protocolo "pensar en voz alta".
- Medir la efectividad de los usuarios al utilizar el sistema.

D.1.3 Fechas, Lugares y Roles

Las sesiones de test se realizarán los días X, Y, Z; realizando cada una de sesiones de test en A, B y C.

La actividad será llevada a cabo por un único investigador, Joaquín Tita, cuyo rol será el de facilitador y observador. Como facilitador, su tarea principal será interactuar directamente con el participante del test realizándole una breve introducción de la actividad que se llevará a cabo. Luego, como observador, durante la ejecución de cada tarea, se encargará de tomar nota de los comentarios del participante y su desarrollo en general.

D.1.4 Usuarios Participantes

Se tiene pensado reclutar alrededor de X personas para la realización de las pruebas de usabilidad y para que su participación sea posible se les explicará que la evaluación se realizará sobre el prototipo. Se piensa dejar en claro que no son ellos los evaluados sino que son representantes de los usuarios tipos a los que va destinada la aplicación, convenciéndolos de que cualquier error o inconveniente durante el test será debido al diseño del prototipo y no culpa suya. Por último, se dejará en claro que la participación en la prueba de usabilidad es voluntaria y no tiene recompensa alguna. Además, usted es libre de abandonar este estudio en cualquier momento y por cualquier motivo sin necesidad de dar explicación alguna.

D.1.5 Secuencia

La secuencia que se tiene planeada seguir en cada sesión del test es la siguiente:

D.1.5.1 Introducción:

Buenos días, antes de comenzar la sesión me gustaría agradecerle por el tiempo y disposición que nos presta para participar en esta actividad. Vamos a realizar el test de usabilidad de una aplicación para pacientes que se encuentran en la Unidad de

Cuidados Intensivos y tienen dificultades para comunicarse con el personal médico o con sus familiares y amigos. A continuación le voy a pedir que rellene un cuestionario de datos personales cuyo fin es complementar de forma estadística los datos que recabemos con la prueba de usabilidad. Luego, tendrá que realizar 9 tareas con el prototipo que le iré indicando una a una a medida que las vaya completando.

Mientras realice las tareas le pido que exprese en voz alta todo lo que vaya pensando de forma que pueda entender qué le sugieren las pantallas del sistema y cómo las interpreta. Asimismo, le pido que diga en voz alta qué está intentando hacer o que tiene planeado hacer al ir usando el sistema.

Tras esto, le pediré que rellene dos cuestionarios para conocer su opinión acerca del sistema. Nos interesa que nos diga todos los problemas que ve en el prototipo y las cosas que no entiende porque indican problemas de diseño y nos sirven para mejorarlo. Le pedimos la mayor sinceridad posible. En ningún momento será usted evaluado sino que se evaluará única y exclusivamente el prototipo.

En los informes y publicaciones que se deriven de este trabajo, en ningún caso se publicará su nombre o datos individuales que permitan identificarlo. Lo que se publique serán datos agregados de todos los participantes. Además, usted es libre de abandonar esta prueba de usabilidad en cualquier momento y por cualquier motivo sin necesidad de dar explicación alguna.

D.1.5.2 Orden de los Cuestionarios y Consentimiento Informado:

Antes de comenzar el test de usabilidad, el participante deberá leer, comprender y firmar un consentimiento informado previamente facilitado por el investigador. Una vez firmado dicho consentimiento, se le dará el cuestionario personal al participante, así se podrá identificar el tipo de usuario que es. Luego de que realice el test de usabilidad, se completará el cuestionario de impresiones. Por último, se le entregará al participante un cuestionario de satisfacción.

D.1.6 Tareas Pedidas a los Participantes

- **Tarea 1 - Cambiar de postura:** Imagínese que ha estado en la misma posición durante muchas horas y comienza a sentir molestias en la espalda. Utilizando el prototipo desde la tablet pídale a una enfermera que le cambie de posición para estar más cómodo.
- **Tarea 2 - Sufrir de mucho frío:** Suponga que ha sido un día caluroso y por lo tanto, el aire acondicionado de la Unidad de Cuidados Intensivos ha estado funcionando todo el día a una temperatura baja. Cercana la medianoche, siente que su cuerpo está helado. Comunique a una enfermera que quiere que lo tapen para calentarse.
- **Tarea 3 - Dolor en un brazo:** Imagine que luego de llevar varios días internado siente un dolor insoportable en su brazo derecho. Utilizando el prototipo comuníquele a la enfermera de su molestia para que lo sepa.
- **Tarea 4 - Problema respiratorio:** Ahora, imagine que luego de pasar una noche dura en la Unidad de Cuidados Intensivos, cuando finalmente puede conciliar el sueño, se despierta a raíz de tener dificultades para respirar. Comunique a una enfermera su dificultad para respirar normalmente.
- **Tarea 5 - Sentir nauseas:** Suponga que ha tenido dolor de cabeza por varias horas y de repente comienza a sentir nauseas. Usando el prototipo en la tablet avise a una enfermera sobre su estado nauseoso.
- **Tarea 6 - Ganas de orinar:** Ahora, imagine que está durmiendo y se despierta porque siente ganas de hacer pis. Llame a una enfermera utilizando el prototipo para comunicarle su intención y para que le traiga una cuña para orinar.
- **Tarea 7 - Nueva enfermera:** Suponga que justo el día de hoy comienza a atenderle una enfermera que usted no reconoce. Además, suponga que siempre le ha gustado saber el nombre de las personas que le atienden. Utilice el prototipo para saber cómo se llama.
- **Tarea 8 - Regar las plantas:** Suponga que en la visita de la tarde su marido/esposa le ha visitado. Durante la misma recuerda que sus plantas han estado un tiempo sin regar. Utilizando el prototipo dígale: **“no te olvides de regar las plantas”**.

- **Tarea 9 - Responder al Doctor:** Imagine que por la mañana se acerca el doctor que suele atenderle y le pregunta si ya ha mejorado del dolor de espalda que tenía el día de ayer. Utilizando el prototipo respóndale que no ha mejorado.

D.1.7 Medidas Objetivas

Se medirán los siguientes parámetros para cada tarea realizada por cada participante:

- Número de acciones elementales empleadas para realizar la tarea.
- Números de errores.
- Si se completa la tarea o no (ratio de tareas completadas por participante).

D.2 Cuestionario Personal

Identificador del participante:

Fecha y Hora:

Por favor, contesta a las siguientes preguntas sobre ti y tu experiencia

Edad:

Género: Varón ☐ Mujer ☐

1. ¿Tienes una teléfono móvil tipo Smartphone (con aplicaciones) o tablet?

   Sí ☐ No ☐

2. En caso de haber respondido afirmativamente la pregunta anterior, ¿Para qué lo utilizas?

3. ¿Cuál es tu ocupación laboral?

4. ¿Has estado en una Unidad de Cuidados Intensivos anteriormente?

5. En caso de haber respondido afirmativamente la pregunta anterior, ¿Por qué dolencia y cuánto tiempo?

D.3 Cuestionario de Impresiones

Identificador de participante:

Fecha y Hora:

1. ¿Cuál es la parte del prototipo que crees que es la más oscura o difícil de entender?

2. ¿Cambiarías algo del prototipo? En caso afirmativo, ¿Qué cosas cambiarías? ¿Por qué?

3. ¿Puedes describir tu experiencia general al usar el prototipo?

4. ¿Le ha faltado alguna funcionalidad al prototipo? En caso afirmativo, ¿Qué le agregarías?

5. ¿Qué característica te ha gustado más del prototipo (en caso de que te haya gustado algo)?

D.4 Cuestionario de Satisfacción SUS

Identificador de participante:

Fecha y Hora:

Valora de 1 a 5 las siguientes afirmaciones, donde 1 significa “estoy en completo desacuerdo” y 5 significa “estoy totalmente de acuerdo”.

	1	**2**	**3**	**4**	**5**
Me gustaría usar el sistema frecuentemente					
El sistema es innecesariamente complejo					
El sistema ha sido fácil de usar					
Necesitaría la ayuda de personal técnico para poder usar este sistema					
Las funciones del sistema están bien integradas					
Hay muchas inconsistencias en el sistema					
La mayoría de las personas podrían aprender rápidamente a usar el sistema					
El sistema es muy incómodo de usar					
Me sentí muy seguro usando el sistema					
Tuve que aprender muchas cosas antes de poder usar el sistema					

D.5 Plantilla para los observadores

Tarea 1 - Cambiar de postura
¿Termina con éxito la tarea? Si ☐ No ☐
Nº de acciones:
Nº de errores:
Observaciones:

Tarea 2 - Sufrir de mucho frío
¿Termina con éxito la tarea? Si ☐ No ☐
Nº de acciones:
Nº de errores:
Observaciones:

Tarea 3 - Dolor en un brazo
¿Termina con éxito la tarea? Si ☐ No ☐
Nº de acciones:
Nº de errores:
Observaciones:

Tarea 4 - Problema respiratorio
¿Termina con éxito la tarea? Si ☐ No ☐
Nº de acciones:
Nº de errores:
Observaciones:

Tarea 5 - Sentir nauseas
¿Termina con éxito la tarea? Si ☐ No ☐
Nº de acciones:
Nº de errores:
Observaciones:

Tarea 6 – Ganas de orinar
¿Termina con éxito la tarea? Si ☐ No ☐
Nº de acciones:
Nº de errores:
Observaciones:

Tarea 7 - Nueva enfermera
¿Termina con éxito la tarea? Si ☐ No ☐
Nº de acciones:
Nº de errores:
Observaciones:

Tarea 8 - Regar las plantas
¿Termina con éxito la tarea? Si ☐ No ☐
Nº de acciones:
Nº de errores:
Observaciones:

Tarea 9 - Responder al doctor
¿Termina con éxito la tarea? Si ☐ No ☐
Nº de acciones:
Nº de errores:
Observaciones: